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THE LIFE OF PASTEUR

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THE LIFE OF PASTEUR

BY RENÉ VALLERY-RADOT

TRANSLATED FROM THE
FRENCH BY MRS. R. L.
DEVONSHIRE

VOL II

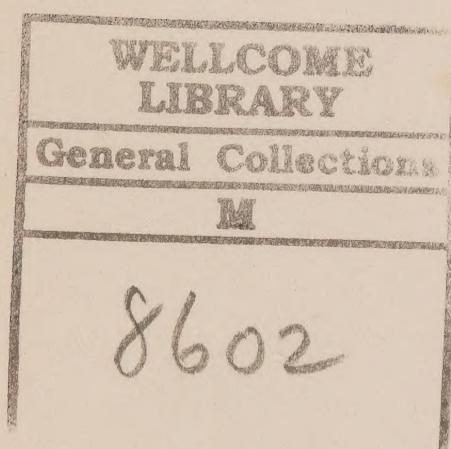
L'oeuvre de Pasteur est admirable; elle montre son génie, mais il faut avoir vécu dans son intimité pour connaître toute la bonté de son coeur.—Dr. Roux

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THE END.

CHAPTER I

1873-1877

PASTEUR had glimpses of another world beyond the phenomena of fermentation—the world of virus ferments. Two centuries earlier, an English physicist, Robert Boyle, had said that he who could probe to the bottom the nature of ferments and fermentation would probably be more capable than any one of explaining certain morbid phenomena. These words often recurred to the mind of Pasteur, who had, concerning the problem of contagious diseases, those sudden flashes of light wherein genius is revealed. But, ever insisting on experimental proofs, he constrained his exalted imagination so as to follow calmly and patiently the road of experimental method. He could not bear the slightest error, or even hasty interpretation, in the praises addressed to him. One day, during the period of the most ardent polemics, in the midst of the struggle on spontaneous generation, a medical man named Déclat, who declared that Pasteur's experiments were "the glory of our century and the salvation of future generations," gave a lecture on "The Infinitesimally Small and their Rôle in the World." "After the lecture," relates Dr. Déclat himself, "M. Pasteur, whom I only knew by name, came to me, and, after the usual compliments, condemned the inductions I had drawn from his experiments. 'The arguments,' he said, 'by which you support

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my theories, are most ingenious, but not founded on demonstrated facts; analogy is no proof.'"

Pasteur used to speak very modestly of his work. He said, in a speech to some Arbois students, that it was "through assiduous work, with no special gift but that of perseverance joined to an attraction towards all that is great and good," that he had met with success in his researches. He did not add that an ardent kindness of heart was ever urging him forward. After the services rendered within the last ten years to vinegar makers, silk-worm cultivators, vine growers, and brewers, he now wished to tackle what he had had in his mind since 1861—the study of contagious diseases. Thus, with the consistent logic of his mind, showing him as it did the possibility of realizing in the future Robert Boyle's prophecy, he associated the secret power of his feelings; not to give those feelings their share would be to leave one side of his nature entirely in the shade. He had himself revealed this great factor in his character when he had said, "It would indeed be a grand thing to give the heart its share in the progress of science." He was ever giving it a greater share in his work.

His sorrows had only made him incline the more towards the griefs of others. The memory of the children he had lost, the mournings he had witnessed, caused him to passionately desire that there might be fewer empty places in desolate homes, and that this might be due to the application of methods derived from his discoveries, of which he foresaw the immense bearings on pathology. Beyond this, patriotism being for him a ruling motive, he thought of the thousands of young men lost to France every year, victims of the tiny germs of murderous diseases. And, at the thought of epidemics and the heavy tax they levy on the whole world, his compassion extended itself to all human suffering.

He regretted that he was not a medical man, fancying that it might have facilitated his task. It was true that, at every incursion on the domain of Medicine, he was looked upon as a chemist—a *chymiaſter*, some said—who was poaching on the preserves of others. The distrust felt by the physicians in the chemists was of a long standing. In the *Traité de Thérapeutique*, published in 1855 by Trousseau and Pidoux, we find this passage: “When a chemist has seen the chemical conditions of respiration, of digestion, or of the action of some drug, he thinks he has given the theory of those functions and phenomena. It is ever the same delusion which chemists will never get over. We must make up our minds to that, but let us beware of trying to profit by the precious researches which they would probably never undertake if they were not stimulated by the ambition of explaining what is outside their range.” Pidoux never retrenched anything from two other phrases, also to be found in that same treatise: “Between a physiological fact and a pathological fact there is the same difference as between a mineral and a vegetable”; and: “It is not within the power of physiology to explain the simplest pathological affection.” Trousseau, on the other hand, was endowed with the far-seeing intelligence of a great physician attentive to the progress of science. He was greatly interested in Pasteur’s work, and fully appreciated the possibilities opened by each of his discoveries.

Pasteur, with the simplicity which contrasted with his extraordinary powers, supposed that, if he were armed with diplomas, he would have greater authority to direct Medicine towards the study of the conditions of existence of phenomena, and—correlatively to the traditional method of observation, which consists in knowing and describing exactly the course of the disease—to inspire practitioners with the desire to prevent and to determine its cause. An

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unexpected offer went some way towards filling what he considered as a blank. At the beginning of the year 1873, a place was vacant in the section of the Free Associates of the Academy of Medicine. He was asked to stand for it, and hastened to accept. He was elected with a majority of only one vote, though he had been first on the section's list. The other suffrages were divided between Messrs. Le Roy de Méricourt, Brochin, Lhéritier, and Bertillon.

Pasteur, as soon as he was elected, promised himself that he would be a most punctual academician. It was on a Tuesday in April that he attended his first meeting. As he walked towards the desk allotted to him, his paralyzed left leg dragging a little, no one among his colleagues suspected that this quiet and unassuming new member would become the greatest revolutionary ever known in Medicine.

One thing added to Pasteur's pleasure in being elected—the fact that he would join Claude Bernard. The latter had often felt somewhat forlorn in that centre, where some hostility was so often to be seen towards all that was outside the Clinic. This was the time when the "princes of science," or those who were considered as such, were all physicians. Every great physician was conscious of being a ruling power. The almost daily habit of advising and counselling was added to that idea of haughty or benevolent superiority to the rest of the world; and, accustomed to dictate his wishes, the physician frequently adopted an authoritative tone and became a sort of personage. "Have you noticed," said Claude Bernard to Pasteur with a smile under which many feelings were hidden, "that, when a doctor enters a room, he always looks as if he was going to say, 'I have just been saving a fellow-man'?"

Pasteur knew not those harmless shafts which are a revenge for prolonged pomposity. Why need Claude

Bernard trouble to wonder what So-and-so might think? He had the consciousness of the work accomplished and the esteem and admiration of men whose suffrage more than satisfied him. Whilst Pasteur was already desirous of spreading in the Académie de Médecine the faith which inspired him, Claude Bernard remembered the refractory state of mind of those who, at the time of his first lectures on experimental physiology applied to medicine, affirmed that "physiology can be of no practical use in medicine; it is but a *science de luxe* which could well be dispensed with." He energetically defended this *science de luxe* as the very science of life. In his opening lecture at the Museum in 1870, he said that "descriptive anatomy is to physiology as geography to history; and, as it is not sufficient to understand the topography of a country to know its history, so is it not enough to know the anatomy of an organ to understand its functions." Méry, an old surgeon, familiarly compared anatomists to those errand boys in large towns, who know the names of the streets and the numbers of the houses, but do not know what goes on inside. There are indeed in tissues and organs physico-chemical phenomena for which anatomy cannot account.

Claude Bernard was convinced that Medicine would gradually emerge from quackery, and this by means of the experimental method, like all other science. "No doubt," he said, "we shall not live to see the blossoming out of scientific medicine, but such is the fate of humanity; those that sow on the field of science are not destined to reap the fruit of their labours." And so saying, Claude Bernard continued to sow.

It is true that here and there flashes of light had preceded Pasteur; but, instead of being guided by them, most doctors continued to advance majestically in the midst of darkness. Whenever murderous diseases, scourges of humanity, were

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in question, long French or Latin words were put forward, such as "Epidemic genius," *fatum, quid ignotum quid divinum*, etc. *Medical constitution* was also a useful word, elastic and applicable to anything.

When the Val de Grâce physician, Villemin—a modest, gentle-voiced man, who, under his quiet exterior, hid a veritable thirst for scientific truth—after experimental researches carried on from 1865 to 1869, brought the proof that tuberculosis is a disease which reproduces itself, and cannot be reproduced but by itself; in a word, specific, inoculable, and contagious, he was treated almost as a perturber of medical order.

Dr. Pidoux, an ideal representative of traditional medicine, with his gold-buttoned blue coat and his reputation equally great in Paris and at the Eaux-Bonnes, declared that the idea of specificity was a fatal thought. Himself a pillar of the doctrine of diathesis and of the morbid spontaneity of the organism, he exclaimed in some much applauded speeches: "Tuberculosis! but that is the common result of a quantity of divers external and internal causes, not the product of a specific agent ever the same!" Was not this disease to be looked upon as "one and multiple at the same time, bringing the same final conclusion, the necrobiotic and infecting destruction of the plasmatic tissue of an organ by a number of roads which the hygienist and physician must endeavour to close." Where would these specificity doctrines lead to? "Applied to chronic diseases, these doctrines condemn us to the research of specific remedies or vaccines, and all progress is arrested. . . . Specificity immobilizes medicine." These phrases were reproduced by the medical press.

The bacillus of tuberculosis had not been discovered by Villemin; it was only found and isolated much later, in 1882, by Dr. Koch; but Villemin suspected the existence

of a virus. In order to demonstrate the infectious nature of tuberculosis, he experimented on animals, multiplying inoculations; he took the sputum of tuberculous patients, spread it on cotton wool, dried it, and then made the cotton wool into a bed for little guinea-pigs, who became tuberculous. Pidoux answered these precise facts by declaring that Villemin was fascinated by inoculation, adding ironically, "Then all we doctors have to do is to set out nets to catch the sporules of tuberculosis, and find a vaccine."

That sudden theory of phthisis, falling from the clouds, resembled Pasteur's theory of germs floating in air. Was it not better, urged Pidoux the heterogenist, to remain in the truer and more philosophical doctrine of spontaneous generation? "Let us believe, until the contrary is proved, that we are right, we partisans of the common etiology of phthisis, partisans of the spontaneous tuberculous degeneration of the organism under the influence of accessible causes, which we seek everywhere in order to cut down the evil in its roots."

A reception somewhat similar to that given to Villemin was reserved for Davaine, who, having meditated on Pasteur's works on butyric ferment and the part played by that ferment, compared it and its action with certain parasites visible with a microscope and observed by him in the blood of animals which had died of charbon disease. By its action and its rapid multiplication in the blood, this agent endowed with life probably acted, said Davaine, after the manner of ferments. The blood was modified to that extent that it speedily brought about the death of the infected animal. Davaine called those filaments found in anthrax "bacteria," and added, "They have a place in the classification of living beings." But what was that animated virus to many doctors? They answered experimental proofs by oratorical arguments.

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At the very time when Pasteur took his seat at the Academy of Medicine, Davaine was being violently attacked ; his experiments on septicæmia were the cause, or the pretext. But the mere tone of the discussions prepared Pasteur for future battles. The theory of germs, the doctrine of virus ferments, all this was considered as a complete reversal of acquired notions, a heresy which had to be suppressed. A well known surgeon, Dr. Chassaignac, spoke before the Académie de Médecine of what he called "laboratory surgery, which has destroyed very many animals and saved very few human beings." In order to remind experimentalists of the distance between them and practitioners, he added: "Laboratory results should be brought out in a circumspect, modest and reserved manner, as long as they have not been sanctioned by long clinical researches, a sanction without which there is no real and practical medical science." Everything, he said, could not be resolved into a question of bacteria! And, ironically, far from realizing the truth of his sarcastic prophecy, he exclaimed, "Typhoid fever, bacterization ! Hospital miasma, bacterization !"

Every one had a word to say. Dr. Piorry, an octogenarian, somewhat weighed down with the burden of his years and reputation, rose to speak with his accustomed solemnity. He had found for Villemin's experiments the simple explanation that "the tuberculous matter seems to be no other than pus, which, in consequence of its sojourn in the organs, has undergone varied and numerous modifications"; and he now imagined that one of the principal causes of fatal accidents due to septicæmia after surgical operations was the imperfect ventilation of hospital wards. It was enough, he thought, that putrid odours should not be perceptible, for the rate of mortality to be decreased.

It was then affirmed that putrid infection was not an

organized ferment, that inferior organisms had in themselves no toxic action, in fact, that they were the result and not the cause of putrid alteration; whereupon Dr. Bouillaud, a contemporary of Dr. Pierry, called upon their new colleague to give his opinion on the subject.

It would have been an act of graceful welcome to Pasteur, and a fitting homage to the memory of the celebrated Troussseau, who had died five years before, in 1867, if any member present had then quoted one of the great practitioner's last lectures at the Hôtel Dieu, wherein he predicted a future for Pasteur's works:

"The great theory of ferments is therefore now connected with an organic function; every ferment is a germ, the life of which is manifested by a special secretion. It may be that it is so for morbid viruses; they may be ferments, which, deposited within the organism at a given moment and under determined circumstances, manifest themselves by divers products. So will the variolous ferment produce variolic fermentation, giving birth to thousands of pustules, and likewise the virus of glanders, that of sheep pox, etc. . . .

"Other viruses appear to act locally, but, nevertheless, they ultimately modify the whole organism, as do gangrene, malignant pustula, contagious erysipelas, etc. May it not be supposed, under such circumstances, that the ferment or organized matter of those viruses can be carried about by the lancet, the atmosphere or the linen bandages?"

But it occurred to no one in the Academy to quote those forgotten words.

Pasteur, answering Bouillaud, recalled his own researches on lactic and butyric fermentations and spoke of his studies on beer. He stated that the alteration of beer was due to the presence of filiform organisms; if beer becomes altered,

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it is because it contains germs of organized ferments. "The correlation is certain, indisputable, between the disease and the presence of organisms." He spoke those last words with so much emphasis that the stenographer who was taking down the extempore speeches underlined them.

A few months later, on November 17, 1873, he read to the Academy a paper containing further developments of his principles. "In order that beer should become altered and become sour, putrid, slimy, 'ropy,' acid or lactic, it is necessary that foreign organisms should develop within it, and those organisms only appear and multiply when those germs are already extant in the liquid mass." It is possible to oppose the introduction of those germs; Pasteur drew on the blackboard the diagram of an apparatus which only communicated with the outer air by means of tubes fulfilling the office of the sinuous necks of the glass vessels he had used for his experiments on so-called spontaneous generations. He entered into every detail, demonstrating that as long as pure yeast alone had been sown, the security was absolute. "That which has been put forward on the subject of a possible transformation of yeast into bacteria, vibriones, *mycoderma aceti* and vulgar mucors, or vice versa, is mistaken."

He wrote in a private letter on the subject: "These simple and clear results have cost me many sleepless nights before presenting themselves before me in the precise form I have now given them."

But his own conviction had not yet penetrated the minds of his adversaries, and M. Trécul was still supporting his hypothesis of transformations, the so-called proofs of which, according to Pasteur, rested on a basis of confused facts tainted with involuntary errors due to imperfect experiments.

In December, 1873, at a sitting of the Academy, he presented M. Trécul with a few little flagons, in which he had sown some pure seed of *penicillium glaucum*, begging him to accept them and to observe them at his leisure, assuring him that it would be impossible to find a trace of any transformation of the spores into yeast cells.

"When M. Trécul has finished the little task which I am soliciting of his devotion to the knowledge of truth," continued Pasteur, "I shall give him the elements of a similar work on the *mycoderma vini*; in other words, I shall bring to M. Trécul some absolutely pure *mycoderma vini* with which he can reproduce his former experiments and recognize the exactness of the facts which I have lately announced."

Pasteur concluded thus: "The Academy will allow me to make one last remark. It must be owned that my contraditors have been peculiarly unlucky in taking the occasion of my paper on the diseases of beer to renew this discussion. How is it they did not understand that my process for the fabrication of inalterable beer could not exist if beer wort in contact with air could present all the transformations of which they speak? And that work on beer, entirely founded as it is on the discovery and knowledge of some microscopic beings, has it not followed my studies on vinegar, on the *mycoderma aceti* and on the new process of acetification which I have invented? Has not that work been followed by my studies on the causes of wine diseases and the means of preventing them, still founded on the discovery and knowledge of non-spontaneous microscopic beings? Have not these last researches been followed by the discovery of means to prevent the silk-worm disease, equally deducted from the study of non-spontaneous microscopic beings?

"Are not all the researches I have pursued for seventeen

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years, at the cost of many efforts, the product of the same ideas, the same principles, pushed by incessant toil into consequences ever new? The best proof that an observer is in the right track lies in the uninterrupted fruitfulness of his work."

This fruitfulness was evidenced, not only by Pasteur's personal labours, but by those he inspired and encouraged. Thus, in that same period, M. Gayon, a former student of the Ecole Normale, whom he had chosen as curator, started on some researches on the alteration of eggs. He stated that when an egg is stale, rotten, this is due to the presence and multiplication of infinitesimally small beings; the germs of those organisms and the organisms themselves come from the oviduct of the hen and penetrate even into the points where the shell membrane and the albumen are formed. "The result is," concluded M. Gayon, "that, during the formation of those various elements, the egg may or may not, according to circumstances, gather up organisms or germs of organisms, and consequently bear within itself, as soon as it is laid, the cause of ulterior alterations. It will be seen at the same time that the number of eggs susceptible of alteration may vary from one hen to another, as well as between the eggs of one hen, for the organisms to be observed on the oviduct rise to variable heights."

If the organisms which alter the eggs and cause them to rot "were formed," said Pasteur, "by the spontaneous self-organization of the matter within the egg into those small beings, all eggs should putrefy equally, whereas they do not." At the end of M. Gayon's thesis—which had not taken so long as Raulin's to prepare, only three years—we find the following conclusion: "Putrefaction in eggs is correlative with the development and multiplication of beings which are bacteria when in contact with air and vibriones when away from the contact of air. Eggs, from

that point of view, do not depart from the general law discovered by M. Pasteur."

Pasteur's influence was now spreading beyond the Laboratory of Physiological Chemistry, as the small laboratory at the Ecole Normale was called.

In the treatise he had published in 1862, criticising the doctrine of spontaneous generation, he had mentioned among the organisms produced by urine in putrefaction, the existence of a torulacea in very small-grained chaplets. A physician, Dr. Traube, in 1864, had demonstrated that Pasteur was right in thinking that ammoniacal fermentation was due to this torulacea, whose properties were afterwards studied with infinite care by M. Van Tieghem, a former student of the Ecole Normale, who had inspired Pasteur with a deep affection. Pasteur, in his turn, completed his own observations and assured himself that this little organized ferment was to be found in every case of ammoniacal urine. Finally, after proving that boracic acid impeded the development of that ammoniacal ferment, he suggested to M. Guyon, the celebrated surgeon, the use of boracic acid for washing out the bladder; M. Guyon put the advice into practice with success, and attributed the credit of it to Pasteur.

In a letter written at the end of 1873, Pasteur wrote: "How I wish I had enough health and sufficient knowledge to throw myself body and soul into the experimental study of one of our infectious diseases!" He considered that his studies on fermentations would lead him in that direction; he thought that when it should be made evident that every serious alteration in beer was due to the micro-organisms which find in that liquid a medium favourable to their development, when it should be seen that—in contradiction to the old ideas by which those alterations are looked upon as spontaneous, inherent in those liquids, and depending on

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their nature and composition—the cause of those diseases is not interior but exterior, then would indeed be defeated the doctrine of men like Pidoux, who, à propos of diseases, said : “Disease is in us, of us, by us,” and who, à propos of small-pox, even said that he was not certain that it could only proceed from inoculation and contagion.

Though the majority of physicians and surgeons considered that it was waste of time to listen to “a mere chemist,” there was a small group of young men, undergraduates, who, in their thirst for knowledge, assembled at the Académie de Médecine every Tuesday, hoping that Pasteur might bring out one of his communications concerning a scientific method “which resolves each difficulty by an easily interpreted experiment, delightful to the mind, and at the same time so decisive that it is as satisfying as a geometrical demonstration, and gives an impression of security.”

Those words were written by one of those who came to the Académie sittings, feeling that they were on the eve of some great revelations. He was a clinical assistant of Dr. Béhier’s, and, busy as he was with medical analysis, he was going over Pasteur’s experiments on fermentations for his own edification. He was delighted with the sureness of the Pastorian methods, and was impatient to continue the struggle now begun. Enthusiasm was evinced in his brilliant eyes, in the timbre of his voice, clear, incisive, slightly imperious perhaps, and in his implacable desire for logic. Of solitary habits, with no ambition for distinction or degrees, he worked unceasingly for sheer love of science. The greatest desire of that young man of twenty-one, quite unknown to Pasteur, was to be one day admitted, in the very humblest rank, to the Ecole Normale laboratory. His name was Roux.

Was not that medical student, that disciple lost in the

crowd, an image of the new generation hungering for new ideas, more convinced than the preceding one had been of the necessity of proofs? Struck by the unstable basis of medical theories, those young men divined that the secret of progress in hospitals was to be found in the laboratories. Medicine and surgery in those days were such a contrast to what they are now that it seems as if centuries divided them. No doubt one day some professor, some medical historian, will give us a full account of that vast and immense progress. But, whilst awaiting a fully competent work of that kind, it is possible, even in a book such as this (which is, from many causes, but a hasty epitome of many very different things spread over a very simple biography), to give to a reader unfamiliar with such studies a certain idea of one of the most interesting chapters in the history of civilization, affecting the preservation of innumerable human lives.

"A pin prick is a door open to Death," said the surgeon Velpeau. That open door widened before the smallest operation; the lancing of an abcess or a whitlow sometimes had such serious consequences that surgeons hesitated before the slightest use of the bistoury. It was much worse when a great surgical intervention was necessary, though, through the irony of things, the immediate success of the most difficult operations was now guaranteed by the progress of skill and the precious discovery of anæsthesia. The patient, his will and consciousness suspended, awoke from the most terrible operation as from a dream. But at that very moment when the surgeon's art was emboldened by being able to disregard pain, it was arrested, disconcerted, and terrified by the fatal failures which supervened after almost every operation. The words pyæmia, gangrene, erysipelas, septicæmia, purulent infection, were bywords in those days.

In the face of those terrible consequences, it had been

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thought better, about forty years ago, to discourage and even to prohibit a certain operation, then recently invented and practised in England and America, ovariotomy, "even," said Velpeau, "if the reported cures be true." In order to express the terror inspired by ovariotomy, a physician went so far as to say that it should be "classed among the attributes of the executioner."

As it was supposed that the infected air of the hospitals might be the cause of the invariably fatal results of that operation, the Assistance Publique¹ hired an isolated house in the Avenue de Meudon, near Paris, a salubrious spot. In 1863, ten women in succession were sent to that house; the neighbouring inhabitants watched those ten patients entering the house, and a short time afterwards their ten coffins being taken away. In their terrified ignorance they called that house the House of Crime.

Surgeons were asking themselves whether they did not carry death with them, unconsciously scattering virus and subtle poisons.

Since the beginning of the nineteenth century, surgery had positively retrograded; the mortality after operations was infinitely less in the preceding centuries, because antisepsis was practised unknowingly, through cauterizations by fire, boiling liquids and disinfecting substances. In a popular handbook published in 1749, and entitled *Medicine and Surgery for the Poor*, we read that wounds should be kept from the contact of air; it was also recommended not to touch the wound with fingers or instruments. "It is very salutary, when uncovering the wound in order to dress it, to begin by applying over its whole surface a piece of cloth dipped into hot wine or brandy." Good results had been obtained by the great surgeon Larrey, under the first

¹ *Assistance Publique*, official organization of the charitable works supported by the State. [Trans.]

Empire, by hot oil, hot brandy, and unfrequent dressings. But, under the influence of Broussais, the theory of inflammation caused a retrogression in surgery. Then came forth basins for making poultices, packets of charpie (usually made of old hospital sheets merely washed), and rows of pots of ointment. It is true that, during the second half of the last century, a few attempts were made to renew the use of alcoholized water for dressings. In 1868, at the time when the mortality after amputation in hospitals was over sixty per cent., Surgeon Léon Le Fort banished sponges, exacted from his students scrupulous cleanliness and constant washing of hands and instruments before every operation, and employed alcoholized water for dressings. But though he obtained such satisfactory results as to lower, in his wards at the Hôpital Cochin, the average of mortality after amputations to twenty-four per cent., his colleagues were very far from suspecting that the first secret for preventing fatal results after operations consisted in a reform of the dressings.

Those who visited an ambulance ward during the war of 1870, especially those who were medical students, have preserved such a recollection of the sight that they do not, even now, care to speak about it. It was perpetual agony, the wounds of all the patients were suppurating, a horrible fetor pervaded the place, and infectious septicæmia was everywhere. "Pus seemed to germinate everywhere," said a student of that time (M. Landouzy, who became a professor at the Faculty of Medicine), "as if it had been sown by the surgeon." M. Landouzy also recalled the words of M. Denonvilliers, a surgeon of the Charité Hospital, whom he calls "a splendid operator, . . . a virtuoso, and a dilettante in the art of operating," who said to his pupils: "When an amputation seems necessary, think ten times about it, for too often, when we decide upon an operation, we sign the patient's

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death-warrant." Another surgeon, who must have been profoundly discouraged in spite of his youthful energy, M. Verneuil, exclaimed: "There were no longer any precise indications, any rational previsions; nothing was successful, neither abstention, conservation, restricted or radical mutilation, early or postponed extraction of the bullets, dressings rare or frequent, emollient or excitant, dry or moist, with or without drainage; we tried everything in vain!" During the siege of Paris, in the Grand Hôtel, which had been turned into an ambulance, Nélaton, in despair at the sight of the death of almost every patient who had been operated on, declared that he who should conquer purulent infection would deserve a golden statue.

It was only at the end of the war that it occurred to Alphonse Guérin—(who to his intense irritation was so often confounded with another surgeon, his namesake and opponent, Jules Guérin)—that "the cause of purulent infection may perhaps be due to the germs or ferments discovered by Pasteur to exist in the air." Alphonse Guérin saw, in malarial fever, emanations of putrefied vegetable matter, and, in purulent infection, animal emanations, septic, and capable of causing death.

"I thought more firmly than ever," he declared, "that the miasms emanating from the pus of the wounded were the real cause of this frightful disease, to which I had the sorrow of seeing the wounded succumb—whether their wounds were dressed with charpie and cerate or with alcoholized and carbolic lotions, either renewed several times a day or impregnating linen bandages which remained applied to the wounds. In my despair—ever seeking some means of preventing these terrible complications—I be-thought me that the miasms, whose existence I admitted, because I could not otherwise explain the production of purulent infection—and which were only known to me by

their deleterious influence—might well be living corpuscles, of the kind which Pasteur had seen in atmospheric air, and, from that moment, the history of miasmatic poisoning became clearer to me. If," I said, "miasms are ferments, I might protect the wounded from their fatal influence by filtering the air, as Pasteur did. I then conceived the idea of cotton-wool dressings, and I had the satisfaction of seeing my anticipations realized."

After arresting the bleeding, ligaturing the blood vessels and carefully washing the wound with carbolic solution or camphorated alcohol, Alphonse Guérin applied thin layers of cotton wool, over which he placed thicker masses of the same, binding the whole with strong bandages of new linen. This dressing looked like a voluminous parcel and did not require to be removed for about twenty days. This was done at the St. Louis Hospital to the wounded of the Commune from March till June, 1871. Other surgeons learnt with amazement that, out of thirty-four patients treated in that way, nineteen had survived operation. Dr. Reclus, who could not bring himself to believe it, said: "We had grown to look upon purulent infection as upon an inevitable and necessary disease, an almost Divinely instituted consequence of any important operation."

There is a much greater danger than that of atmospheric germs, that of the contagium germ, of which the surgeon's hands, sponges and tools are the receptacle, if minute and infinite precautions are not taken against it. Such precautions were not even thought of in those days; charpie, odious charpie, was left lying about on hospital and ambulance tables, in contact with dirty vessels. It had, therefore, been sufficient to institute careful washing of the wounds, and especially to reduce the frequency of dressings, and so diminish the chances of infection to obtain—thanks to a reform inspired by Pasteur's labours—this

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precious and unexpected remedy to fatalities subsequent to operations. In 1873, Alphonse Guérin, now a surgeon at the Hôtel Dieu, submitted to Pasteur all the facts which had taken place at the hospital St. Louis, where surgery was more "active," he said, than at the Hôtel Dieu; he asked him to come and see his cotton-wool dressings, and Pasteur gladly hastened to accept the invitation. It was with much pleasure that Pasteur entered upon this new period of visits to hospitals and practical discussions with his colleagues of the Académie de Médecine. His joy at the thought that he had been the means of awakening in other minds ideas likely to lead to the good of humanity was increased by the following letter from Lister, dated from Edinburgh, February 13, 1874, which is here reproduced in the original—

"My dear Sir—allow me to beg your acceptance of a pamphlet, which I send by the same post, containing an account of some investigations into the subject which you have done so much to elucidate, the germ theory of fermentative changes. I flatter myself that you may read with some interest what I have written on the organism which you were the first to describe in your *Mémoire sur la fermentation appelée lactique*.

"I do not know whether the records of British *Surgery* ever meet your eye. If so, you will have seen from time to time notices of the antiseptic system of treatment, which I have been labouring for the last nine years to bring to perfection.

"Allow me to take this opportunity to tender you my most cordial thanks for having, by your brilliant researches, demonstrated to me the truth of the germ theory of putrefaction, and thus furnished me with the principle upon which alone the antiseptic system can be carried out.

Should you at any time visit Edinburgh, it would, I believe, give you sincere gratification to see at our hospital how largely mankind is being benefited by your labours.

"I need hardly add that it would afford me the highest gratification to show you how greatly surgery is indebted to you.

"Forgive the freedom with which a common love of science inspires me, and

"Believe me, with profound respect,

"Yours very sincerely,

"JOSEPH LISTER."

In Lister's wards, the instruments, sponges and other articles used for dressings were first of all purified in a strong solution of carbolic acid. The same precautions were taken for the hands of the surgeon and of his assistants. During the whole course of each operation, a vaporizer of carbolic solution created around the wound an antiseptic atmosphere ; after it was over, the wound was again washed with the carbolic solution. Special articles were used for dressing : a sort of gauze, similar to tarlatan and impregnated with a mixture of resin, paraffin and carbolic, maintained an antiseptic atmosphere around the wound. Such was—in its main lines—Lister's method.

A medical student, M. Just Lucas-Championnière—who later on became an exponent in France of this method, and who described it in a valuable treatise published in 1876—had already in 1869, after a journey to Glasgow, stated in the *Journal de médecine et de chirurgie pratique* what were those first principles of defence against gangrene—"extreme and minute care in the dressing of wounds." But his isolated voice was not heard ; neither was any notice taken of a celebrated lecture given by Lister at the beginning of 1870 on the penetrating of germs into a purulent

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centre and on the utility of antisepsis applied to clinical practice. A few months before the war, Tyndall, the great English physicist, alluded to this lecture in an article entitled "Dusts and Diseases," which was published by the *Revue des cours scientifiques*. But the heads of the profession in France had at that time absolute confidence in themselves, and nobody took any interest in the rumour of success attained by the antiseptic method. Yet, between 1867 and 1869, thirty-four of Lister's patients out of forty had survived after amputation. It is impossible on reading of this not to feel an immense sadness at the thought of the hundreds and thousands of young men who perished in ambulances and hospitals during the fatal year, and who might have been saved by Lister's method. In his own country, Lister had also been violently criticized. "People turned into ridicule Lister's minute precautions in the dressing of wounds," writes a competent judge, Dr. Auguste Reaudin, a professor at the Geneva Faculty of Medicine, "and those who lost nearly all their patients by poulticing them had nothing but sarcasms for the man who was so infinitely superior to them." Lister, with his calm courage and smiling kindness, let people talk, and endeavoured year by year to perfect his method, testing it constantly and improving it in detail. No one, however sceptical, whom he invited to look at his results, could preserve his scepticism in the face of such marked success.

Some of his opponents thought to attack him on another point by denying him the priority of the use of carbolic acid. Lister never claimed that priority, but his enemies took pleasure in recalling that Jules Lemaire, in 1860, had proposed the use of weak carbolic solution for the treatment of open wounds, and that the same had been prescribed by Dr. Déclat in 1861, and also by Maisonneuve, Demarquay and others. The fact that should have been

proclaimed was that Lister had created a surgical method which was in itself an immense and beneficial progress; and Lister took pleasure in declaring that he owed to Pasteur the principles which had guided him.

At the time when Pasteur received the letter above quoted, which gave him deep gratification, people in France were so far from all that concerned antisepsis and asepsis, that, when he advised surgeons at the Académie de Médecine to put their instruments through a flame before using them, they did not understand what he meant, and he had to explain—

“I mean that surgical instruments should merely be put through a flame, not really heated, and for this reason: if a sound were examined with a microscope, it would be seen that its surface presents grooves where dusts are harboured, which cannot be completely removed even by the most careful cleansing. Fire entirely destroys those organic dusts; in my laboratory, where I am surrounded with dust of all kinds, I never make use of an instrument without previously putting it through a flame.”

Pasteur was ever ready to help others, giving them willing advice or information. In November, 1874, when visiting the Hôtel Dieu with Messrs. Larrey and Gosselin, he had occasion to notice that a certain cotton-wool dressing had been very badly done by a student in one of Guérin’s wards. A wound on the dirty hand of a labouring man had been bandaged with cotton wool without having been washed in any way. When the bandaging was removed in the presence of Guérin, the pus exhaled a repugnant odour, and was found to swarm with vibriones. Pasteur, in a sitting of the Académie des Sciences, entered into details as to the precautions which are necessary to get rid of the germs originally present on the surface of the wound or of the cotton wool; he declared that the layers of cotton

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wool should be heated to a very high temperature. He also suggested the following experiment: "In order to demonstrate the evil influence of ferments and proto-organisms in the suppuration of wounds, I would make two identical wounds on the two symmetrical limbs of an animal under chloroform; on one of those wounds I would apply a cotton-wool dressing with every possible precaution; on the other, on the contrary, I would cultivate, so to speak, micro-organisms abstracted from a strange sore, and offering, more or less, a septic character.

"Finally, I should like to cut open a wound on an animal under chloroform in a very carefully selected part of the body—for the experiment would be a very delicate one—and in absolutely pure air, that is, air absolutely devoid of any kind of germs, afterwards maintaining a pure atmosphere around the wound, and having recourse to no dressing whatever. I am inclined to think that perfect healing would ensue under such conditions, for there would be nothing to hinder the work of repair and reorganization which must be accomplished on the surface of a wound if it is to heal."

He explained in that way the advantage accruing to hygiene, in hospitals and elsewhere, from infinite precautions of cleanliness and the destroying of infectious germs. Himself a great investigator of new ideas, he intended to compel his colleagues at the Académie de Médecine to include the pathogenic share of the infinitesimally small among matters demanding the attention of medicine and surgery. The struggle was a long, unceasing and painful one. In February, 1875, his presence gave rise to a discussion on ferments, which lasted until the end of March. In the course of this discussion he recalled the experiments he had made fifteen years before, describing how—in a liquid composed of mineral elements, apart

from the contact of atmospheric air and previously raised to ebullition—vibriones could be sown and subsequently seen to flourish and multiply, offering the sight of those two important phenomena : life without air, and fermentation.

“ They are far behind us now,” he said ; “ they are now relegated to the rank of chimeras, those theories of fermentation imagined by Berzelius, Mitscherlich, and Liebig, and re-edited with an accompaniment of new hypotheses by Messrs. Pouchet, Frémy, Trécul, and Béchamp. Who would now dare to affirm that fermentations are contact phenomena, phenomena of motion, communicated by an altering albuminoid matter, or phenomena produced by semi-organized materia, transforming themselves into this or into that ? All those creations of fancy fall to pieces before this simple and decisive experiment.”

Pasteur ended up his speech by an unexpected attack on the pompous etiquette of the Academy’s usual proceedings, urging his colleagues to remain within the bounds of a scientific discussion instead of making flowery speeches. He was much applauded, and his exhortation taken in good part. His colleagues also probably sympathized with his irritation in hearing a member of the assembly, M. Poggiale, formerly apothecary in chief to the Val de Grâce, give a somewhat sceptical dissertation on such a subject as spontaneous generation, saying disdainfully—

“ M. Pasteur has told us that he had looked for spontaneous generation for twenty years without finding it ; he will long continue to look for it, and, in spite of his courage, perseverance and sagacity, I doubt whether he ever will find it. It is almost an unsolvable question. However those who, like me, have no fixed opinion on the question of spontaneous generation reserve the right of verifying, of sifting and of disputing new facts, as they appear, one by one and wherever they are produced.”

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"What!" cried Pasteur, wrathful whenever those great questions were thoughtlessly tackled, "what! I have been for twenty years engaged in one subject and I am not to have an opinion! and the right of verifying, sifting, and disputing the facts is to belong to him who does nothing to become enlightened but merely to read our works more or less attentively, his feet on his study fender !!!"

"You have no opinion on spontaneous generation, my dear colleague; I can well believe that, while regretting it. I am not speaking, of course, of those sentimental opinions that everybody has, more or less, in questions of this nature, for in this assembly we do not go in for sentiment. You say that, in the present state of science, it is wiser to have no opinion: well, I have an opinion, not a sentimental one, but a rational one, having acquired a right to it by twenty years of assiduous labour, and it would be wise in every impartial mind to share it. My opinion—nay more, my conviction—is that, in the present state of science, as you rightly say, spontaneous generation is a chimera; and it would be impossible for you to contradict me, for my experiments all stand forth to prove that spontaneous generation is a chimera. What is then your judgment on my experiments? Have I not a hundred times placed organic matter in contact with pure air in the best conditions for it to produce life spontaneously? Have I not practised on those organic materia which are most favourable, according to all accounts, to the genesis of spontaneity, such as blood, urine, and grape juice? How is it that you do not see the essential difference between my opponents and myself? Not only have I contradicted, proof in hand, every one of their assertions, while they have never dared to seriously contradict one of mine, but, for them, every cause of error benefits their opinion. For me, affirming as I do that there are no spontaneous fermentations, I am

bound to eliminate every cause of error, every perturbing influence, I can maintain my results only by means of most irreproachable experiments; their opinions, on the contrary, profit by every insufficient experiment and that is where they find their support."

Pasteur having been abruptly addressed by a colleague, who remarked that there were yet many unexplained facts in connection with fermentation, he answered by thus apostrophizing his adversaries—

"What is then your idea of the progress of Science? Science advances one step, then another, and then draws back and meditates before taking a third. Does the impossibility of taking that last step suppress the success acquired by the two others? Would you say to an infant who hesitated before a third step, having ventured on two previous ones: 'Thy former efforts are of no avail; never shalt thou walk'?"

"You wish to upset what you call my theory, apparently in order to defend another; allow me to tell you by what signs these theories are recognized: the characteristic of erroneous theories is the impossibility of ever foreseeing new facts; whenever such a fact is discovered, those theories have to be grafted with further hypotheses in order to account for them. True theories, on the contrary, are the expression of actual facts and are characterized by being able to predict new facts, a natural consequence of those already known. In a word, the characteristic of a true theory is its fruitfulness."

"Science," said he again at the following sitting of the Academy, "should not concern itself in any way with the philosophical consequences of its discoveries. If through the development of my experimental studies I come to demonstrate that matter can organize itself of its own accord into a cell or into a living being, I would come

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here to proclaim it with the legitimate pride of an inventor conscious of having made a great discovery, and I would add, if provoked to do so, "All the worse for those whose doctrines or systems do not fit in with the truth of the natural facts."

"It was with similar pride that I defied my opponents to contradict me when I said, "In the present state of science the doctrine of spontaneous generation is a chimera." And I add, with similar independence, "All the worse for those whose philosophical or political ideas are hindered by my studies."

"This is not to be taken to mean that, in my beliefs and in the conduct of my life, I only take account of acquired science: if I would, I could not do so, for I should then have to strip myself of a part of myself. There are two men in each one of us: the scientist, he who starts with a clear field and desires to rise to the knowledge of Nature through observation, experimentation and reasoning, and the man of sentiment, the man of belief, the man who mourns his dead children and who cannot, alas, prove that he will see them again, but who believes that he will, and lives in that hope, the man who will not die like a vibrio, but who feels that the force that is within him cannot die. The two domains are distinct, and woe to him who tries to let them trespass on each other in the so imperfect state of human knowledge."

And that separation, as he understood it, caused in him none of those conflicts which often determine a crisis in a human soul. As a scientist, he claimed absolute liberty of research; he considered, with Claude Bernard and Littré that, it was a mistaken waste of time to endeavour to penetrate primary causes; "we can only note correlations," he said. But, with the spiritual sentiment which caused him to claim for the inner moral life the same liberty as for

scientific research, he could not understand certain givers of easy explanations who affirm that matter has organized itself, and who, considering as perfectly simple the spectacle of the Universe of which Earth is but an infinitesimal part, are in no wise moved by the Infinite Power who created the worlds. With his whole heart he proclaimed the immortality of the soul.

His mode of looking upon human life, in spite of sorrows, of struggles, of heavy burdens, had in it a strong element of consolation : "No effort is wasted," he said, giving thus a most virile lesson of philosophy to those inferior minds who only see immediate results in the work they undertake and are discouraged by the first disappointment. In his respect for the great phenomenon of Conscience, by which almost all men, enveloped as they are in the mystery of the Universe, have the prescience of an Ideal, of a God, he considered that "the greatness of human actions can be measured by the inspirations which give them birth." He was convinced that there are no vain prayers. If all is simple to the simple, all is great to the great; it was through "the Divine regions of Knowledge and of Light" that he had visions of those who are no more.

It was very seldom that he spoke of such things, though he was sometimes induced to do so in the course of a discussion so as to manifest his repugnance for vainglorious negations and barren irony; sometimes too he would enter into such feelings when speaking to an assembly of young men.

Those discussions at the Academy of Medicine had the advantage of inciting medical men to the research of the infinitesimally small, described by the Annual Secretary Roger as "those subtle artisans of many disorders in the living economy."

M. Roger, at the end of a brief account of his colleague's

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work, wrote, "To the signal services rendered by M. Pasteur to science and to our country, it was but fair that a signal recompense should be given: the National Assembly has undertaken that care."

That recompense, voted a few months previously, was the third national recompense accorded to French scientists since the beginning of the century. In 1837, Arago, before the Chamber of Deputies, and Gay Lussac before the Chamber of Peers, had obtained a glorious recognition of the services rendered by Daguerre and Niepce. In 1845 another national recompense was accorded to M. Vicat, the engineer. In 1874, Paul Bert, a member of the National Assembly, gladly reporting on the projected law tending to offer a national recompense to Pasteur, wrote quoting those precedents:

"Such an assurance of gratitude, given by a nation to men who have made it richer and more illustrious, honours it at least as much as it does them. . . ." Paul Bert continued by enumerating Pasteur's discoveries, and spoke of the millions Pasteur had assured to France, "without retaining the least share of them for himself." In sericulture alone, the losses in twenty years, before Pasteur's interference, rose to 1,500 millions of francs.

"M. Pasteur's discoveries, gentlemen," concluded Paul Bert, "after throwing a new light on the obscure question of fermentations and of the mode of appearance of microscopic beings, have revolutionized certain branches of industry, of agriculture, and of pathology. One is struck with admiration when seeing that so many, and such divers results, proceed—through an unbroken chain of facts, nothing being left to hypothesis—from theoretical studies on the manner in which tartaric acid deviates polarized light. Never was the famous saying, 'Genius consists in sufficient patience' more amply justified. The Government now pro-

poses that you should honour this admirable combination of theoretical and practical study by a national recompense; your Commission unanimously approves of this proposition.

"The suggested recompense consists in a life annuity of 12,000 francs, which is the approximate amount of the salary of the Sorbonne professorship, which M. Pasteur's ill health has compelled him to give up. It is indeed small when compared with the value of the services rendered, and your Commission much regrets that the state of our finances does not allow us to increase that amount. But the Commission agrees with its learned chairman (M. Marès) 'that the economic and hygienic results of M. Pasteur's discoveries will presently become so considerable that the French nation will desire to increase later on its testimony of gratitude towards him and towards Science, of which he is one of the most glorious representatives.'

Half the amount of the annuity was to revert to Pasteur's widow. The Bill was passed by 532 votes against 24.

"Where is the government which has secured such a majority?" wrote Pasteur's old friend Chappuis, now Rector of the Grenoble Academy. The value of the recompense was certainly much enhanced by the fact that the Assembly, divided upon so many subjects, had been almost unanimous in its feeling of gratitude towards him who had laboured so hard for Science, for the country and for Humanity.

"Bravo, my dear Pasteur: I am glad for you and for myself, and proud for us all. Your devoted friend, Sainte Claire Deville."

"You are going to be a happy scientist," wrote M. Duclaux, for you can already see, and you will see more and more, the triumph of your doctrines and of your discoveries."

Those who imagined that this national recompense was

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the close of a great chapter, perhaps even the last chapter of the book of his life, gave him, in their well meaning ignorance, some advice which highly irritated him: they advised him to rest. It is true that his cerebral hemorrhage had left him with a certain degree of lameness and a slight stiffness of the left hand, those external signs reminding him only too well of the threatening possibility of another stroke; but his mighty soul was more than ever powerful to master his infirm body. It was therefore evident that Nisard, usually very subtle in his insight into character, did not thoroughly understand Pasteur when he wrote to him, "Now, dear friend, you must give up your energies to living for your family, for all those who love you, and a little too for yourself."

In spite of his deep, even passionate tenderness for his family, Pasteur had other desires than to limit his life to such a narrow circle. Every man who knows he has a mission to fulfil feels that there are rays of a light purer and more exalted than that proceeding from the hearth. As to the suggestion that Pasteur should take care of his own health, it was as useless as it would be to advise certain men to take care of that of others.

Dr. Andral had vainly said and written that he should forbid Pasteur any assiduous labour. Pasteur considered that not to work was to lose the object of living at all. If, however, a certain equilibrium was established between the anxious solicitude of friends, the prohibitions of medical advisers and the great amount of work which Pasteur insisted on doing, it was owing to her who with a discreet activity watched in silence to see that nothing outside his work should complicate Pasteur's life, herself his most precious collaborator, the confidante of every experiment.

Everything was subordinate to the laboratory; Pasteur never accepted an invitation to those large social gatherings

which are a tax laid by those who have nothing to do on the time of those who are busy, especially if they be celebrated. Pasteur's name, known throughout the world, was never mentioned in fashionable journals ; he did not even go to theatres. In the evening, after dinner, he usually perambulated the hall and corridor of his rooms at the Ecole Normale, cogitating over various details of his work. At ten o'clock, he went to bed, and at eight the next morning, whether he had had a good night or a bad one, he resumed his work in the laboratory.

That regular life, preserving its even tenor through so many polemics and discussions, was momentarily perturbed by politics in January, 1876. Pasteur, who, in his extraordinary, almost disconcerting, modesty believed that a medical diploma would have facilitated his scientific revolution, imagined—after the pressing overtures made to him by some of his proud compatriots—that he would be able to serve more usefully the cause of higher education if he were to obtain a seat at the Senate.

He addressed from Paris a letter to the senatorial electors of the department of Jura. "I am not a political man," he said, "I am bound to no party ; not having studied politics, I am ignorant of many things, but I do know this, that I love my country and have served her with all my strength." Like many good citizens, he thought that a renewal of the national grandeur and prosperity might be sought in a serious experimental trial of the Republic. If honoured with the suffrages of his countrymen, he would "represent in the Senate, Science in all its purity, dignity and independence." Two Jura newspapers, of different opinions, agreed in regretting that Pasteur should leave "the peaceful altitudes of science," and come down into the Jura to solicit the electors' suffrages.

In his answers to such articles, letters dictated to his son

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—who acted as his secretary during that electoral campaign and accompanied him to Lons-le-Saulnier, where they spent a week, published addresses, posters, etc.—Pasteur invoked the following motto, “*Science et Patrie.*” Why had France been victorious in 1792? “Because Science had given to our fathers the material means of fighting.” And he recalled the names of Monge, of Carnot, of Fourcroy, of Guyton de Morveau, of Berthollet, that concourse of men of science, thanks to whom it had been possible—during that grandiose epoch—to hasten the working of steel and the preparation of leather for soldiers’ boots, and to find means of extracting saltpetre for gunpowder from plaster rubbish, of making use of reconnoitring balloons and of perfecting telegraphy.

The senatorial electors numbered 650. Jules Grévy came to Lons-le-Saulnier to support the candidature of MM. Tamisier and Thurel. In a meeting which took place the day before the election he said, “You will give them your suffrage to-morrow, and in so doing you will have deserved well of the Republic and of France.” He mentioned, incidentally, that “M. Pasteur’s character and scientific work entitle him to universal respect and esteem; but Science has its natural place at the Institute,” he added, insisting on the Senate’s political attributes. Grévy’s intervention in favour of his two candidates was decisive. M. Tamisier obtained 446 votes, M. Thurel 445, General Picard 113, M. Besson, a monarchist, 153, Pasteur 62 only.

He had received on that very morning a letter from his daughter, wishing him a failure—a bright, girlish letter, frankly expressing the opinion that her father could be most useful to his country by confining himself to laboratory work, and that politics would necessarily hinder such work.

It was easy to be absolutely frank with Pasteur, who

willingly accepted every truthful statement. No man was ever more beloved, more admired, and less flattered in his own home than he was.

"What a wise judge you are, my dearest girl!" answered Pasteur the same evening; "you are perfectly right. But I am not sorry to have seen all this, and that your brother should have seen it; all knowledge is useful."

That little incursion into the domain of politics was rendered insignificant in Pasteur's life by the fact that his long-desired object was almost reached. Three months later, at the distribution of prizes of the *Concours Général*, the Minister of Public Instruction pronounced a speech, of which Pasteur preserved the text, underlining with his own hand the following passages: "Soon, I hope, we shall see the Schools of Medicine and of Pharmacy reconstructed; the Collège de France provided with new laboratories; the Faculty of Medicine transferred and enlarged, and the ancient Sorbonne itself restored and extended."

And while the Minister spoke of "those higher studies of Philosophy, of History, of disinterested Science which are the glory of a nation and an honour to the human mind . . . which must retain the first rank to shed their serene light over inferior studies, and to remind men of the true goal and the true grandeur of human intelligence. . ." Pasteur could say to himself that the great cause which he had pleaded since he was made Dean of Faculty at Lille in 1854, which he had supported in 1868 and again on the morrow of the war, was at last about to be won in 1876.

He had a patriotic treat during the summer holidays of that same year. A great international congress of sericulture was gathered at Milan; there were delegates from Russia, Austria, Italy and France, and Pasteur represented France. He was accompanied by his former pupils, his associates in his silkworm studies, Duclaux and Raulin,

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both of whom had become professors at the Lyons Faculty of Sciences, and Maillot, who was then manager of the silkworm establishment of Montpellier. The members of the Congress had been previously informed of the programme of questions, and each intending speaker was armed with facts and observations. The open discussions allowed Duclaux, Raulin and Maillot to demonstrate the strictness and perfection of the experimental method which they had learned from their master and which they were teaching in their turn.

Excursions formed a delightful interlude; one on the lake of Como was an enchantment. Then the French delegates were offered the pleasant surprise of a visit to an immense seeding establishment in the neighbourhood of Milan, which had been named after Pasteur. We have an account of this visit in a letter to J. B. Dumas (September 17).

"My dear Master . . . I very much regret that you are not here: you would have shared my satisfaction. I am dating my letter from Milan, but in reality, the congress being ended, we are staying at Signor Susani's country house for a few days. Here, from July 4, sixty or seventy women are busy for ten hours every day with microscopic examinations of absolute accuracy. I never saw a better arranged establishment. 400,000 moth cells are put under the microscope every day. The order and cleanliness are admirable; any error is made impossible by the organization of a second test following the first."

"I felt, in seeing my name in large letters on the façade of that splendid establishment, a joy which compensates for much of the frivolous opposition I have encountered from some of my countrymen these last few years; it is a spontaneous homage from the proprietor to my studies. Many sericicultors do their seeding themselves, by selection, or have it done by competent workers accustomed to the operation.

The harvest from that excellent seed depends on the climate only; in a moderately favourable season the production often reaches fifty or seventy kilogrammes per ounce of twenty-five grammes."

Signor Susani was looking forward to producing for that one year 30,000 ounces of seed. In the presence of the prodigious activity of this veritable factory—where, besides the microscope women, more than one hundred persons were occupied in various ways, washing the mortars with which the moths are pounded before being put under the microscopes, cleansing the slides, etc.; in fact, doing those various delicate but simple operations which had formerly been pronounced to be impracticable—Pasteur's thoughts went back to his experiments in the Pont-Gisquet greenhouse, to the modest beginnings of his process, now so magnificently applied in Italy. A month before this, J. B. Dumas, presiding at a scientific meeting at Clermont Ferrand, had said—

"The future belongs to Science; woe to the nations who close their eyes to this fact . . . Let us call to our aid on this neutral and pacific ground of Natural Philosophy, where defeats cost neither blood nor tears, those hearts which are moved by their country's grandeur; it is by the exaltation of science that France will recover her prestige."

Those same ideas were expressed in a toast given by Pasteur in the name of France at a farewell banquet, when the 300 members of the Sericulture Congress were present.

"Gentlemen, I propose a toast—To the peaceful strife of Science. It is the first time that I have the honour of being present on foreign soil at an international congress; I ask myself what are the impressions produced in me, besides these courteous discussions, by the brilliant hospitality of the noble Milanese city, and I find myself deeply impressed

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by two propositions. First, that Science is of no nationality ; and secondly, in apparent, but only in apparent, contradiction, that Science is the highest personification of nationality. Science has no nationality because knowledge is the patrimony of humanity, the torch which gives light to the world. Science should be the highest personification of nationality because, of all the nations, that one will always be foremost which shall be first to progress by the labours of thought and of intelligence.

"Let us therefore strive in the pacific field of Science for the pre-eminence of our several countries. Let us strive, for strife is effort, strife is life when progress is the goal.

" You Italians, try to multiply on the soil of your beautiful and glorious country the Tecchi, the Brioschi, the Tacchini, the Sella, the Cornalia. . . . You, proud children of Austria-Hungary, follow even more firmly than in the past the fruitful impulse which an eminent statesman, now your representative at the Court of England, has given to Science and Agriculture. We, who are here present, do not forget that the first sericulture establishment was founded in Austria. As to you, Japanese, may the cultivation of Science be numbered among the chief objects of your care in the amazing social and political transformation of which you are giving the marvellous spectacle to the world. We Frenchmen, bending under the sorrow of our mutilated country, should show once again that great trials may give rise to great thoughts and great actions.

" I drink to the peaceful strife of Science."

" You will find," wrote Pasteur to Dumas, telling him of this toast, which had been received with enthusiastic applause, "an echo of the feelings with which you have inspired your pupils on the grandeur and the destiny of Science in modern society."

The tender and delicate side of this powerful spirit was thus once again apparent in this deference to his master in the midst of acclamations, and in those deep and noble ideas expressed in the middle of a noisy banquet. But it was chiefly in his private life that his open-heartedness, his desire to love and to be loved, became apparent. That great genius had a childlike heart, and the charm of this was incomparable.

He once said: "The recompense and the ambition of a scientist is to conquer the approbation of his peers and of the masters whom he venerates." He had already known that recompense and could satisfy that ambition. Dumas had known and appreciated him for thirty years; Lister had proclaimed his gratitude; Tyndall—an indefatigable excursionist, who loved to survey wide horizons, and who in his celebrated classes was wont to make use of comparisons with altitudes and heights and everything which opens a clear and vast outlook—had a great admiration for the wide development of Pasteur's work. Now, Pasteur's experiments had been strongly attacked by a young English physician, Dr. Bastian, who had excited in the English and American public a bitter prejudice against the results announced by Pasteur on the subject of spontaneous generation.

"The confusion and uncertainty," wrote Tyndall to Pasteur, "have finally become such that, six months ago, I thought that it would be rendering a service to Science, at the same time as justice to yourself, if the question were subjected to a fresh investigation.

"Putting into practice an idea which I had entertained six years ago—the details of which are set out in the article in the *British Medical Journal* which I had the pleasure to send you—I went over a large portion of the ground on which Dr. Bastian had taken up his stand, and refuted,

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I think, many of the fallacies which had misled the public.

"The change which has taken place since then in the tone of the English medical journals is quite remarkable, and I am disposed to think that the general confidence of the public in the accuracy of Dr. Bastian's experiments has been considerably shaken.

"In taking up these investigations, I have had the opportunity of refreshing my memory about your labours; they have reawakened in me all the admiration which I felt for them when I first read of them. I intend to continue these investigations until I have dispersed all the doubts which may have arisen as to the indisputable accuracy of your conclusions."

And Tyndall added a paragraph for which Pasteur modestly substituted asterisks in communicating this letter to the Academy.

"For the first time in the history of Science we have the right to cherish the sure and certain hope that, as regards epidemic diseases, medicine will soon be delivered from quackery and placed on a real scientific basis. When that day arrives, Humanity, in my opinion, will know how to recognize that it is to you that will be due the largest share of her gratitude."

Tyndall was indeed qualified to sign this passport to immortality. But in the meanwhile a struggle was necessary, and Pasteur did not wish to leave the burden of the discussion even on such shoulders as Tyndall's! Moreover he was interested in his opponent.

"Dr. Bastian," writes M. Duclaux, "had some tenacity, a fertile mind, and the love, if not the gift, of the experimental method." The discussion was destined to last for months. In general (according to J. B. Dumas' calculation) "at the end of ten years, judgment on a great thing is usually formed; it is by then an accomplished fact, an

idea adopted by Science or irrevocably repudiated." Pasteur, on the morrow of the Milan Congress, might feel that it had been so for the adoption of his system of cellular seeding, but such was not the case in this question of spontaneous generation. The quarrel had started again at the Academy of Sciences and at the Academy of Medicine; it was now being revived in England, and Bastian proposed to come himself and experiment in the laboratory of the Ecole Normale.

"For nearly twenty years," said Pasteur, "I have pursued, without finding it, a proof of life existing without an anterior and similar life. The consequences of such a discovery would be incalculable; natural science in general, and medicine and philosophy in particular, would receive therefrom an impulse which cannot be foreseen. Therefore, whenever I hear that this discovery has been made, I hasten to verify the assertions of my fortunate rival. It is true that I hasten towards him with some degree of mistrust, so many times have I experienced that, in the difficult art of experimenting, the very cleverest stagger at every step, and that the interpretation of facts is no less perilous."

Dr. Bastian operated on acid urine, boiled and neutralized by a solution of potash heated to a temperature of 120°C . If, after the flask of urine had cooled down, it was heated to a temperature of 50°C . in order to facilitate the development of germs, the liquid in ten hours' time swarmed with bacteria. "Those facts prove spontaneous generation," said Dr. Bastian.

Pasteur invited him to replace his boiled solution of potash by a fragment of solid potash, after heating it to 110°C ., in order to avoid the bacteria germs which might be contained in the aqueous solution. This question of the germs of inferior organisms possibly contained in water

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was—during the course of that protracted discussion—studied by Pasteur with the assistance of M. Joubert, Professor of Physics at the Collège Rollin. Such germs were to be found even in the distilled water of laboratories; it was sufficient that the water should be poured in a thin stream through the air to become contaminated. Spring water, if slowly filtered through a solid mass of ground, alone contained no germs.

There was also the question of the urine and that of the recipient. The urine, collected by Dr. Bastian in a vase and placed into a retort, neither of which had been put through a flame, might contain spores of a bacillus called *bacillus subtilis*, which offer a great resistance to the action of heat. Those spores do not develop in notably acid liquids, but the liquid having been neutralized or rendered slightly alkaline by the potash, the development of germs took place. The thing therefore to be done was to collect the urine in a vase and introduce it into a retort both of which had been put through a flame. After that, no organisms were produced, as was stated in the thesis of M. Chamberland, then a curator at the laboratory, and who took an active part in these experiments.

A chapter might well have been written by a moralist “On the use of certain opponents”; for it was through that discussion with Bastian that it was discovered how it was that—at the time of the celebrated discussions on spontaneous generation—the heterogenists, Pouchet, Joly, and Musset, operating as Pasteur did, but in a different medium, obtained results apparently contradictory to Pasteur’s. If their flasks, filled with a decoction of hay, almost constantly showed germs, whilst Pasteur’s, full of yeast water, were always sterile, it was because the hay water contained spores of the *bacillus subtilis*. The spores remained inactive as long as the liquid was preserved from

the contact of air, but as soon as oxygen re-entered the flask they were able to develop.

The custom of raising liquids to a temperature of 120° C. in order to sterilize them dates from that conflict with Bastian. "But," writes M. Duclaux, "the heating to 120° of a flask half filled with liquid can sterilize the liquid part only, allowing life to persist in those regions which are not in contact with the liquid. In order to destroy everything, the dry walls must be heated to 180° C."

A former pupil of the Ecole Normale, who had been a curator in Pasteur's laboratory since October, 1876, Boutroux by name, who witnessed all these researches, wrote in his thesis: "The knowledge of these facts makes it possible to obtain absolutely pure neutral culture mediums, and, in consequence, to study as many generations as are required of one unmixed micro-organism, whenever pure seed has been procured."

Pasteur has defined what he meant by putting tubes, cotton, vases, etc., through a flame. "In order to get rid of the microscopic germs which the dusts of air and of the water used for the washing of vessels deposit on every object, the best means is to place the vessels (their openings closed with pads of cotton wool) during half an hour in a gas stove, heating the air in which the articles stand to a temperature of about 150° C. to 200° C. The vessels, tubes, etc., are then ready for use. The cotton wool is enclosed in tubes or in blotting-paper."

What Pasteur had recommended to surgeons, when he advised them to pass through a flame all the instruments they used, had become a current practice in the laboratory; the least pad of cotton-wool used as a stopper was previously sterilized. Thus was an entirely new technique rising fully armed and ready to repel new attacks and ensure new victories.

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If Pasteur was so anxious to drive Dr. Bastian to the wall, it was because he saw behind that so-called experiment on spontaneous generation a cause of perpetual conflict with physicians and surgeons. Some of them desired to repel purely and simply the whole theory of germs. Others, disposed to admit the results of Pasteur's researches, as laboratory work, did not admit his experimental incursions on clinical ground. Pasteur therefore wrote to Dr. Bastian in the early part of July, 1877—

"Do you know why I desire so much to fight and conquer you? it is because you are one of the principal adepts of a medical doctrine which I believe to be fatal to progress in the art of healing—the doctrine of the spontaneity of all diseases . . . That is an error which, I repeat it, is harmful to medical progress. From the prophylactic as well as from the therapeutic point of view, the fate of the physician and surgeon depends upon the adoption of the one or the other of these two doctrines."

CHAPTER II

1877 - 1879

THE confusion of ideas on the origin of contagious and epidemic diseases was about to be suddenly enlightened; Pasteur had now taken up the study of the disease known as charbon or splenic fever. This disease was ruining agriculture; the French provinces of Beauce, Brie, Burgundy, Nivernais, Berry, Champagne, Dauphiné and Auvergne, paid a formidable yearly tribute to this mysterious scourge. In the Beauce, for instance, twenty sheep out of every hundred died in one flock; in some parts of Auvergne the proportion was ten or fifteen per cent., sometimes even twenty-five, thirty-five, or fifty per cent. At Provins, at Meaux, at Fontainebleau, some farms were called *charbon farms*; elsewhere, certain fields or hills were looked upon as accursed and an evil spell seemed to be thrown over flocks bold enough to enter those fields or ascend those hills. Animals stricken with this disease almost always died in a few hours; sheep were seen to lag behind the flock, with drooping head, shaking limbs and gasping breath; after a rigor and some sanguinolent evacuations, occurring also through the mouth and nostrils, death supervened, often before the shepherd had had time to notice the attack. The carcase rapidly became distended, and the least rent in the skin gave issue to a flow of black, thick and viscid blood, hence the name of *anthrax* given

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to the disease. It was also called splenic fever, because necropsy showed that the spleen had assumed enormous dimensions; if that were opened, it presented a black and liquid pulp. In some places the disease assumed a character of extreme virulence; in the one district of Novgorod, in Russia, 56,000 head of cattle died of splenic infection between 1867 and 1870. Horses, oxen, cows, sheep, everything succumbed, as did also 528 persons, attacked by the contagion under divers forms; a pin prick or a scratch is sufficient to inoculate shepherds, butchers, knackers or farmers with the malignant pustule.

Though a professor at the Alfort Veterinary School, M. Delafond, did point out to his pupils as far back as 1838 that charbon blood contained "little rods," as he called them; it was only looked upon by himself and them as a curiosity with no scientific importance. Davaine, when he—and Rayer as well—recognized in 1850 those little filiform bodies in the blood of animals dying of splenic fever, he too merely mentioned the fact, which seemed to him of so little moment that he did not even report it in the first notice of his works edited by himself.

It was only eleven years later that Davaine—struck, as he himself gladly acknowledged, by reading Pasteur's paper on the butyric ferment, the little cylindrical rods of which offer all the characteristics of vibriones or bacteria—asked himself whether the filiform corpuscles seen in the blood of the charbon victims might not act after the manner of ferments and be the cause of the disease. In 1863, a medical man at Dourdan, whose neighbour, a farmer, had lost twelve sheep of charbon in a week, sent blood from one of these sheep to Davaine, who hastened to inoculate some rabbits with this blood. He recognized the presence of those little transparent and motionless rods which he called bacteridia (a diminutive of bacterium, or rod-

shaped vibriones). It might be thought that the cause of the evil was found, in other words that the relation between those bacteridia and the disease which had caused death could not be doubted. But two professors of the Val de Grâce, Jaillard and Leplat, refuted these experiments.

They had procured, in the middle of the summer, from a knacker's yard near Chartres, a little blood from a cow which had died of anthrax, and they inoculated some rabbits with it. The rabbits died, but without presenting any bacteridia. Jaillard and Leplat therefore affirmed that splenic fever was not an affection caused by parasites, that the bacteridium was an epiphénoménon of the disease and could not be looked upon as the cause of it.

Davaine, on repeating Jaillard and Leplat's experiments, found a new interpretation ; he alleged that the disease they had inoculated was not anthrax. Then Jaillard and Leplat obtained a little diseased sheep's blood from M. Boutet, a veterinary surgeon at Chartres, and tried that instead of cow's blood. The result was identical: death ensued, but no bacteridia. Were there then two diseases ?

Others made observations in their turn. It occurred to a young German physician, Dr. Koch, who in 1876 was beginning his career in a small village in Germany, to seek a culture medium for the bacteridium. A few drops of aqueous humour, collected in the eyes of oxen or of rabbits, seemed to him favourable. After a few hours of this nutrition the rods seen under the microscope were ten or twenty times larger than at first; they lengthened immoderately, so as to cover the whole slide of the microscope, and might have been compared to a ball of tangled thread. Dr. Koch examined those lengths, and after a certain time noticed little spots here and there looking like a punctuation of spores. Tyndall, who knew how to secure continuous attention by a variety of

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comparisons, said at a scientific conference in Glasgow a few months later that those little ovoid bodies were contained within the envelope of the filament like peas in their pods. It is interesting to note that Pasteur, when he studied, in connexion with silkworm diseases, the mode of reproduction of the vibrios of flachery, had seen them divide into spores similar to shining corpuscles; he had demonstrated that those spores, like seeds of plants, could revive after a lapse of years and continue their disastrous work. The bacterium of charbon, or *bacillus anthracis* as it now began to be called, reproduced itself in the same way, and, when inoculated by Dr. Koch into guineapigs, rabbits and mice, provoked splenic fever as easily and inevitably as blood from the veins of an animal that had died of the disease. Bacilli and spores therefore yielded the secret of the contagion, and it seemed that the fact was established, when Paul Bert, in January, 1877, announced to the *Société de Biologie* that it was "possible to destroy the bacillus anthracis in a drop of blood by compressed oxygen, to inoculate what remained, and to reproduce the disease and death without any trace of the bacteridium . . . Bacteridia," he added, "are therefore neither the cause nor the necessary effect of splenic fever, which must be due to a virus."

Pasteur tackled the subject. A little drop of the blood of an animal which had died of anthrax—a microscopic drop—was laid, sown, after the usual precautions to ensure purity, in a sterilized balloon which contained neutral or slightly alkaline urine. The culture medium might equally be common household broth, or beer-yeast water, either of them neutralized by potash. After a few hours, a sort of flake was floating in the liquid; the bacteridia could be seen, not under the shape of short broken rods, but with the appearance of filaments, tangled like a skein; the

culture medium being highly favourable, they were rapidly growing longer. A drop of that liquid, abstracted from the first vessel, was sown into a second vessel, of which one drop was again placed into a third, and so on, until the fortieth flask; the seed of each successive culture came from a tiny drop of the preceding one. If a drop from one of those flasks was introduced under the skin of a rabbit or guinea-pig, splenic fever and death immediately ensued, with the same symptoms and characteristics as if the original drop of blood had been inoculated. In the presence of the results from those successive cultures, what became of the hypothesis of an inanimate substance contained in the first drop of blood? It was now diluted in a proportion impossible to imagine. It would therefore be absurd, thought Pasteur, to imagine that the last virulence owed its power to a virulent agent existing in the original drop of blood; it was to the bacteridium, multiplied in each culture, and to the bacteridium alone, that this power was due; the life of the bacteridium had made the virulence. "Anthrax is therefore," Pasteur declared, "the disease of the bacteridium, as trichinosis is the disease of the trichina, as itch is the disease of its special acarus, with this circumstance, however, that, in anthrax, the parasite can only be seen through a microscope, and very much enlarged." After the bacteridium had presented those long filaments, within a few hours, two days at the most, another spectacle followed; amidst those filaments, appeared the oval shapes, the germs, spores or seeds, pointed out by Dr. Koch. Those spores, sown in broth, reproduced in their turn the little packets of tangled filaments, the bacteridia. Pasteur reported that "one single germ of bacteridium in the drop which is sown multiplies during the following hours and ends by filling the whole liquid with such a thickness of bacteridia that, to the naked eye,

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it seems that carded cotton has been mixed with the broth."

M. Chamberland, a pupil who became intimately associated with this work on anthrax, has defined as follows what Pasteur had now achieved: "By his admirable process of culture outside organism, Pasteur shows that the rods which exist in the blood, and for which he has preserved the name of bacteridia given them by Davaine, are living beings capable of being indefinitely reproduced in appropriate liquids, after the manner of a plant multiplied by successive cuttings. The bacterium does not reproduce itself only under the filamentous form, but also through spores or germs, after the manner of many plants which present two modes of reproduction, by cuttings and by seeds." The first point was therefore settled. The ground suspected and indicated by Davaine was now part of the domain of science, and preserved from any new attacks.

Yet Jaillard and Leplat's experiments remained to be explained: how had they provoked death through the blood of a splenic fever victim and found no bacteridia afterwards? It was then that Pasteur, guided, as Tyndall expressed it, by "his extraordinary faculty of combining facts with the reasons of those facts," placed himself, to begin with, in the conditions of Jaillard and Leplat, who had received, during the height of the summer, some blood from a cow and a sheep which had died of anthrax, that blood having evidently been abstracted more than twenty-four hours before the experiment. Pasteur, who had arranged to go to the very spot, the knacker's yard near Chartres, and himself collect diseased blood, wrote to ask that the carcasses of animals which had died of splenic fever should be kept for him for two or three days.

He arrived on June 13, 1877, accompanied by the veterinary surgeon, M. Boutet. Three carcasses were await-

ing him: that of a sheep which had been dead sixteen hours, that of a horse whose death dated from the preceding day, and that of a cow which must have been dead for two or three days, for it had been brought from a distant village. The blood of the recently deceased sheep contained bacteridia of anthrax only. In the blood of the horse, putrefaction vibrios were to be found, besides the bacteridia, and those vibrios existed in a still greater proportion in the blood of the cow. The sheep's blood, inoculated into guinea-pigs, provoked anthrax with pure bacteridia; that of the cow and of the horse brought a rapid death with no bacteridia.

Henceforth what had happened in Jaillard and Leplat's experiments, and in the incomplete and uncertain experiments of Davaine, became simple and perfectly clear to Pasteur, as well as the confusion caused by another experimentalist who had said his say ten years after the discussions of Jaillard, Leplat and Davaine.

This was a Paris veterinary surgeon, M. Signol. He had written to the Academy of Sciences that it was enough that a healthy animal should be felled, or rather asphyxiated, for its blood, taken from the deeper veins, to become violently virulent within sixteen hours. M. Signol thought he had seen motionless bacteridia similar to the bacillus anthracis; but those bacteridia, he said, were incapable of multiplying in the inoculated animals. Yet the blood was so very virulent that animals rapidly succumbed in a manner analogous to death by splenic fever. A Commission was nominated to ascertain the facts; Pasteur was made a member of it, as was also his colleague Bouillaud—still so quick and alert, in spite of his eighty years, that he looked less like an old man than like a wrinkled young man—and another colleague, twenty years younger, Bouley, the first veterinary surgeon in France who had a seat at

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the Institute. The latter was a tall, handsome man, with a somewhat military appearance, and an expression of energetic good humour which his disposition fully justified. He was eager to help in the propagation of new ideas and discoveries, and soon, with eager enthusiasm, placed his marked talents as a writer and orator at Pasteur's disposal.

On the day when the Commission met, M. Signol showed the carcase of a horse, which he had sacrificed for this experiment, having asphyxiated it when in excellent health. Pasteur uncovered the deep veins of the horse and showed to Bouley, and also to Messrs. Joubert and Chamberland, a long vibrio, so translucent as to be almost invisible, creeping, flexible, and which, according to Pasteur's comparison, slipped between the globules of the blood as a serpent slips between high grasses ; it was the septic vibrio. From the peritoneum, where it swarms, that vibrio passes into the blood a few hours after death ; it represents the vanguard of the vibriones of putrefaction. When Jaillard and Leplat had asked for blood infected with anthrax, they had received blood which was at the same time septic. It was septicæmia (so prompt in its action that inoculated rabbits or sheep perish in twenty-four or thirty-six hours) that had killed Jaillard and Leplat's rabbits. It was also septicæmia, provoked by this vibrio (or its germs, for it too has germs), that M. Signol had unknowingly inoculated into the animals upon which he experimented. Successive cultures of that septic vibrio enabled Pasteur to show, as he had done for the bacillus anthracis, that one drop of those cultures caused septicæmia in an animal. But, while the bacillus anthracis is aërobic, the septic vibrio, being anaërobic, must be cultivated in a vacuum, or in carbonic acid gas. And, cultivating those bacteridia and those vibriones with at least as much care as a Dutchman might give to rare tulips, Pasteur

succeeded in parting the bacillus anthracis and the septic vibrio when they were temporarily associated. In a culture in contact with air, only bacteridia developed, in a culture preserved from air, only the septic vibrio.

What Pasteur called "the Paul Bert fact" now alone remained to be explained; this also was simple. The blood Paul Bert had received from Chartres was of the same quality as that which Jaillard and Leplat had had; that is to say already septic. If filaments of bacillus anthracis and of septic vibrios perish under compressed oxygen, such is not the case with the germs, which are extremely tenacious; they can be kept for several hours at a temperature of $70^{\circ}\text{C}.$, and even of $95^{\circ}\text{C}.$. Nothing injures them, neither lack of air, carbonic acid gas or compressed oxygen. Paul Bert, therefore, killed filamentous bacteridia under the influence of high pressure; but, as the germs were none the worse, those germs revived the splenic fever. Paul Bert came to Pasteur's laboratory, ascertained facts and watched experiments. On June 23, 1877, he hastened to the Société de Biologie and proclaimed his mistake, acting in this as a loyal Frenchman, Pasteur said.

In spite of this testimony, and notwithstanding the admiration conceived for Pasteur by certain medical men—notably H. Gueneau de Mussy, who published in that very year (1877) a paper on the theory of the contagium germ and the application of that theory to the etiology of typhoid fever—the struggle was being continued between Pasteur and the current medical doctrines. In the long discussion which began at that time in the Académie de Médecine on typhoid fever, some masters of medical oratory violently attacked the germ theory, proclaiming the spontaneity of living organism. Typhoid fever, they said, is engendered by ourselves within ourselves. Whilst Pasteur was convinced that the day would come—and that was indeed the

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supreme goal of his life work—when contagious and virulent diseases would be effaced from the preoccupations, mournings and anxieties of humanity, and when the infinitesimally small, known, isolated and studied, would at last be vanquished, his ideas were called Utopian dreams.

The old professors, whose career had been built on a combination of theories which they were pleased to call medical truth, dazed by such startling novelties, endeavoured, as did Piorry, to attract attention to their former writings. "It is not the disease, an abstract being," said Piorry, "which we have to treat, but the patient, whom we must study with the greatest care by all the physical, chemical and clinical means which Science offers."

The contagion which Pasteur showed, appearing clearly in the disorders visible in the carcases of inoculated guinea-pigs, was counted as nothing. As to the assimilation of a laboratory experiment on rabbits and guinea-pigs to what occurred in human pathology, it may be guessed that it was quite out of the question for men who did not even admit the possibility of a comparison between veterinary medicine and the other. It would be interesting to reconstitute these hostile surroundings in order to appreciate the efforts of will required of Pasteur to enable him to triumph over all the obstacles raised before him in the medical and the veterinary world.

The Professor of Alfort School, Colin, who had, he said, made 500 experiments on anthrax within the last twelve years, stated, in a paper of seventeen pages, read at the Academy of Medicine on July 31, that the results of Pasteur's experiments had not the importance which Pasteur attributed to them. Among many other objections, one was considered by Colin as a fatal one—the existence of a virulent agent situated in the blood, besides the bacteridia.

Bouley, who had just communicated to the Academy of Sciences some notes by M. Toussaint, professor at the Toulouse veterinary school, whose experiments agreed with those of Pasteur, was nevertheless a little moved by Colin's reading. He wrote in that sense to Pasteur, who was then spending his holidays in the Jura. Pasteur addressed to him an answer as vigorous as any of his replies at the Academy.

"Arbois, August 18, 1877.—My dear colleague . . . I hasten to answer your letter. I should like to accept literally the honour which you confer upon me by calling me 'your master,' and to give you a severe reprimand, you faithless man, who would seem to have been shaken by M. Colin's reading at the Académie des Sciences, since you are still holding forth on the possibility of a virulent agent, and since your uncertainties seem to be appeased by a new notice, read by yourself, last Monday, at the Académie des Sciences.

"Let me tell you frankly that you have not sufficiently imbibed the teaching contained in the papers I have read, in my own name and in that of M. Joubert, at the Académie des Sciences and at the Academy of Medicine. Can you believe that I should have read those papers if they had wanted the confirmation you mention, or if M. Colin's contradictions could have touched them? You know what my situation is, in these grave controversies; you know that, ignorant as I am of medical and veterinary knowledge, I should immediately be taxed with presumption if I had the boldness to speak without being armed for struggle and for victory! All of you, physicians and veterinary surgeons, would quite reasonably fall upon me if I brought into your debates a mere semblance of proof.

"How is it that you have not noticed that M. Colin has travestied—I should even say suppressed—because it hindered

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his theory, the important experiment of the successive cultures of the bacteridium in urine?

"If a drop of blood, infected with anthrax, is mixed with water, with pure blood or with humour from the eye, as was done by Davaine, Koch and M. Colin himself, and some of that mixture is inoculated and death ensues, doubt may remain in the mind as to the cause of virulence, especially since Davaine's well known experiments on septicæmia. Our experiment is very different . . ."

And Pasteur showed how, from one artificial culture to another, he reached the fiftieth, the hundredth, and how a drop of this hundredth culture, identical with the first, could bring about death as certainly as a drop of infected blood.

Months passed, and—as Pasteur used to wish in his youth that it might be—few passed without showing one step forward. In a private letter to his old Arbois school-fellow, Jules Vercel, he wrote (February 11, 1878): "I am extremely busy; at no epoch of my scientific life have I worked so hard or been so much interested in the results of my researches, which will, I hope, throw a new and a great light on certain very important branches of medicine and of surgery."

In the face of those successive discoveries, every one had a word to say. This accumulation of facts was looked down upon by that category of people who borrow assurance from a mixture of ignorance or prejudice. Others, on the other hand, amongst whom the greatest were to be found, proclaimed that Pasteur's work was immortal and that the word "theory" used by him should be changed into that of "doctrine." One of those who thus spoke with the right given by full knowledge, was Dr. Sébillot, whose open and critical mind had kept him from becoming like the old men described by Sainte Beuve as stopping their watch at a

given time and refusing to recognize further progress. He was formerly Director of the Army Medical School at Strasburg, and had already retired in 1870, but had joined the army again as volunteer surgeon. It will be remembered that he had written from the Haguenau ambulance to the Académie des Sciences—of which he was a corresponding member—to call the attention of his colleagues to the horrors of purulent infection, which defied his zeal and devotion.

No one followed Pasteur's work with greater attention than this tall, sad-looking old man of seventy-four; he was one of those who had been torn away from his native Alsace, and he could not get over it. In March, 1878, he read a paper to the Academy, entitled, "On the Influence of M. Pasteur's Work on Medicine and Surgery."

Those discoveries, he said, which had deeply modified the state of surgery, and particularly the treatment of wounds, could be traced back to one principle. This principle was applicable to various facts, and explained Lister's success, and the fact that certain operations had become possible, and that certain cases, formerly considered hopeless, were now being recorded on all sides. Real progress lay there. Sédillot's concluding paragraph deserves to be handed down as a comment precious from a contemporary: "We shall have seen the conception and birth of a new surgery, a daughter of Science and of Art, which will be one of the greatest wonders of our century, and with which the names of Pasteur and Lister will remain gloriously connected."

In that treatise, Sédillot invented a new word to characterize all that body of organisms and infinitely small vibrones, bacteria, bacteridia, etc.; he proposed to designate them all under the generic term of *microbe*. This word had, in Sédillot's eyes, the advantage of being short and of having a general signification. He however felt some scruple

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before using it, and consulted Littré, who replied on February 26, 1878: "Dear colleague and friend, *microbe* and *microbia* are very good words. To designate the animalculæ I should give the preference to *microbe*, because, as you say, it is short, and because it leaves *microbia*, a feminine noun, for the designation of the state of a microbe."

Certain philologists criticized the formation of the word in the name of the Greek language. Microbe, they said, means an animal with a short life, rather than an infinitesimally small animal. Littré gave a second testimonial to the word microbe—

"It is true," he wrote to Séillot, "that *μικρόβιος* and *μακρόβιος* probably mean in Greek *short-lived* and *long-lived*. But, as you justly remark, the question is not what is most purely Greek, but what is the use made in our language of the Greek roots. Now the Greek has *βίος*, life, *βιοῦν*, to live, *βιούς*, living, the root of which may very well figure under the form of *bi*, *bia* with the sense *living*, in *aërobias*, *anaërobias* and *microbe*. I should advise you not to trouble to answer criticisms, but let the word stand for itself, which it will no doubt do." Pasteur, by adopting it, made the whole world familiar with it.

Though during that month of March, 1878, Pasteur had had the pleasure of hearing Séillot's prophetic words at the Académie des Sciences, he had heard very different language at the Académie de Médecine. Colin of Alfort, from the isolated corner where he indulged in his misanthropy, had renewed his criticisms of Pasteur. As he spoke unceasingly of a state of virulent anthrax devoid of bacteridia, Pasteur, losing patience, begged of the Académie to nominate a Commission of Arbitration.

"I desire expressly that M. Colin should be urged to demonstrate what he states to be the fact, for his assertion implies another, which is that an organic matter, contain-

ing neither bacteridia nor germs of bacteridia, produces within the body of a living animal the bacteridia of anthrax. This would be the spontaneous generation of the bacillus *anthracis*!"

Colin's antagonism to Pasteur was such that he contradicted him in every point and on every subject. Pasteur having stated that birds, and notably hens, did not take the charbon disease, Colin had hastened to say that nothing was easier than to give anthrax to hens; this was in July, 1877. Pasteur, who was at that moment sending Colin some samples of bacteridia culture which he had promised him, begged that he would kindly bring him in exchange a hen suffering from that disease, since it could contract it so easily.

Pasteur told the story of this episode in March, 1878; it was an amusing interlude in the midst of those technical discussions. "At the end of the week, I saw M. Colin coming into my laboratory, and, even before I shook hands with him, I said to him: 'Why, you have not brought me that diseased hen?'—'Trust me,' answered M. Colin, 'you shall have it next week.'—I left for the vacation; on my return, and at the first meeting of the Academy which I attended, I went to M. Colin and said, 'Well, where is my dying hen?' 'I have only just begun experimenting again,' said M. Colin; 'in a few days I will bring you a hen suffering from charbon.'—Days and weeks went by, with fresh insistence on my part and new promises from M. Colin. One day, about two months ago, M. Colin owned to me that he had been mistaken, and that it was impossible to give anthrax to a hen. 'Well, my dear colleague,' I said to him, 'I will show you that it is possible to give anthrax to hens; in fact, I will one day myself bring you at Alfort a hen which shall die of charbon.'

"I have told the Academy this story of the hen M. Colin

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had promised in order to show that our colleague's contradiction of our observations on charbon had never been very serious."

Colin, after speaking about several other things, ended by saying: "I regret that I have not until now been able to hand to M. Pasteur a hen dying or dead of anthrax. The two that I had bought for that purpose were inoculated several times with very active blood, but neither of them has fallen ill. Perhaps the experiment might have succeeded afterwards, but, one fine day, a greedy dog prevented that by eating up the two birds, whose cage had probably been badly closed." On the Tuesday which followed this incident, the passers-by were somewhat surprised to see Pasteur emerging from the Ecole Normale, carrying a cage, within which were three hens, one of them dead. Thus laden, he took a fiacre, and drove to the Académie de Médecine, where, on arriving, he deposited this unexpected object on the desk. He explained that the dead hen had been inoculated with charbon two days before, at twelve o'clock on the Sunday, with five drops of yeast water employed as a nutritive liquid for pure bacteridium germs, and that it had died on the Monday at five o'clock, twenty-nine hours' after the inoculation. He also explained, in his own name, and in the names of Messrs. Joubert and Chamberland, how in the presence of the curious fact that hens were refractory to charbon, it had occurred to them to see whether that singular and hitherto mysterious preservation did not have its cause in the temperature of a hen's body, "higher by several degrees than the temperature of the body of all the animal species which can be decimated by charbon."

This preconceived idea was followed by an ingenious experiment. In order to lower the temperature of an inoculated hen's body, it was kept for some time in a bath,

the water covering one-third of its body. When treated in that way, said Pasteur, the hen dies the next day. "All its blood, spleen, lungs, and liver are filled with bacilli anthracis susceptible of ulterior cultures either in inert liquids or in the bodies of animals. We have not met with a single exception."

As a proof of the success of the experiment, the white hen lay on the floor of the cage. As people might be forthcoming, even at the Academy, who would accuse the prolonged bath of having caused death, one of the two living hens, a gray one, who was extremely lively, had been placed in the same bath, at the same temperature and during the same time. The third one, a black hen, also in perfect health, had been inoculated at the same time as the white hen, with the same liquid, but with ten drops instead of five, to make the comparative result more convincing; it had not been subjected to the bath treatment. "You can see how healthy it is," said Pasteur; "it is therefore impossible to doubt that the white hen died of charbon; besides, the fact is proven by the bacteridia which fill its body."

A fourth experiment remained to be tried on a fourth hen, but the Academy of Medicine did not care to hold an all-night sitting. Time lacking, it was only done later, in the laboratory. Could a hen, inoculated of charbon and placed in a bath, recover and be cured merely by being taken out of its bath? A hen was taken, inoculated and held down a prisoner in a bath, its feet fastened to the bottom of the tub, until it was obvious that the disease was in full progress. The hen was then taken out of the water, dried, and wrapped up in cotton wool and placed in a temperature of 35° C. The bacteridia were reabsorbed by the blood, and the hen recovered completely.

This was, indeed, a most suggestive experiment, proving that the mere fall of temperature from 42° C. (the tempera-

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ture of hens) to 38° C. was sufficient to cause a receptive condition ; the hen, brought down by immersion to the temperature of rabbits or guinea-pigs, became a victim like them.

Between Sébillot's enthusiasm and Colin's perpetual contradiction, many attentive surgeons and physicians were taking a middle course, watching for Pasteur's results and ultimately accepting them with admiration. Such was the state of mind of M. Lereboullet, an editor of the *Weekly Gazette of Medicine and Surgery*, who wrote in an account of the Académie de Médecine meeting that " those facts throw a new light on the theory of the genesis and development of the bacillus anthracis. They will be ascertained and verified by other experimentalists, and it seems very probable that M. Pasteur, who never brings any premature or conjectural assertion to the academic tribune, will deduce from them conclusions of the greatest interest concerning the etiology of virulent diseases."

But even to those who admired Pasteur as much as did M. Lereboullet, it did not seem that such an important part should immediately be attributed to microbes. Towards the end of his report (dated March 22, 1878) he reminded his readers that a discussion was open at the Académie de Médecine, and that the surgeon, Léon Le Fort, did not admit the germ theory in its entirety. M. Le Fort recognised " all the services rendered to surgery by laboratory studies, chiefly by calling attention to certain accidents of wounds and sores, and by provoking new researches with a view to improving methods of dressing and bandaging." " Like all his colleagues at the Academy, and like our eminent master, M. Sébillot," added M. Lereboullet, " M. Le Fort renders homage to the work of M. Pasteur ; but he remains within his rights as a practitioner and reserves his opinion as to its general application to surgery."

This was a mild way of putting it; M. Le Fort's words were, "That theory, in its applications to clinical surgery, is absolutely unacceptable." For him, the original purulent infection, though coming from the wound, was born under the influence of general and local phenomena *within* the patient, and not *outside* him. He believed that the economy had the power, under various influences, to produce purulent infection. A septic poison was created, born spontaneously, which was afterwards carried to other patients by such medicines as the tools and bandages and the hands of the surgeon. But, originally, before the propagation of the contagium germ, a purulent infection was spontaneously produced and developed. And, in order to put his teaching into forcible words, M. Le Fort declared to the Académie de Médecine: "I believe in the *interiority* of the principle of purulent infection in certain patients; that is why I oppose the extension to surgery of the germ theory which proclaims the constant *exteriority* of that principle."

Pasteur rose, and with his firm, powerful voice, exclaimed, "Before the Academy accepts the conclusion of the paper we have just heard, before the application of the germ theory to pathology is condemned, I beg that I may be allowed to make a statement of the researches I am engaged in with the collaboration of Messrs. Joubert and Chamberland."

His impatience was so great that he formulated then and there some headings for the lecture he was preparing, propositions on septicæmia or putrid infection, on the septic vibrio itself, on the germs of that vibrio carried by wind in the shape of dust, or suspended in water, on the vitality of those germs, etc. He called attention to the mistakes which might be made if, in that new acquaintance with microbes, their morphologic aspect alone was taken account of. "The septic vibrio, for instance, varies so much in its

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shape, length and thickness, according to the media wherein it is cultivated, that one would think one was dealing with beings specifically distinct from each other."

It was on April 30, 1878, that Pasteur read that celebrated lecture on the germ theory, in his own name and in that of Messrs. Joubert and Chamberland. It began by a proud exordium: "All Sciences gain by mutual support. When, subsequently to my early communications on fermentations, in 1857-1858, it was admitted that ferments, properly so called, are living beings; that germs of microscopical organisms abound on the surface of all objects in the atmosphere and in water; that the hypothesis of spontaneous generations is a chimera; that wines, beer, vinegar, blood, urine and all the liquids of the economy are preserved from their common changes when in contact with pure air—Medicine and Surgery cast their eyes towards these new lights. A French physician, M. Davaine, made a first successful application of those principles to medicine in 1863."

Pasteur himself, elected to the Académie des Sciences as a mineralogist, proved by the concatenation of his studies within the last thirty years that Science was indeed one and all embracing. Having thus called his audience's attention to the bonds which connect one scientific subject with another, Pasteur proceeded to show the connection between his yesterday's researches on the etiology of Charbon to those he now pursued on septicæmia. He hastily glanced back on his successful cultures of the bacillus anthracis, and on the certain, indisputable proof that the last culture acted equally with the first in producing charbon within the body of animals. He then owned to the failure, at first, of a similar method of cultivating the septic vibrio: "All our first experiments failed in spite of the variety of culture media that we used; beer yeast water, meat broth, etc., etc. . . ."

He then expounded, in the most masterly manner: (1) the idea which had occurred to him that this vibrio might be an exclusively anaërobic organism, and that the sterility of the liquids might proceed from the fact that the vibrio was killed by the oxygen held in a state of solution by those liquids; (2) the similarity offered by analogous facts in connection with the vibrio of butyric fermentation, which not only lives without air, but is killed by air; (3) the attempts made to cultivate the septic vibrio in a vacuum or in the presence of carbonic acid gas, and the success of both those attempts; and, finally, as the result of the foregoing, the proof obtained that the action of the air kills the septic vibriones, which are then seen to perish, under the shape of moving threads, and ultimately to disappear, as if burnt away by oxygen.

"If it is terrifying," said Pasteur, "to think that life may be at the mercy of the multiplication of those infinitesimally small creatures, it is also consoling to hope that Science will not always remain powerless before such enemies, since it is already now able to inform us that the simple contact of air is sometimes sufficient to destroy them. But," he continued, meeting his hearers' possible arguments, "if oxygen destroys vibriones, how can septicæmia exist, as it does, in the constant presence of atmospheric air? How can those facts be reconciled with the germ theory? How can blood exposed to air become septic through the dusts contained in air? All is dark, obscure and open to dispute when the cause of the phenomena is not known; all is light when it is grasped."

In a septic liquid exposed to the contact of air, vibriones die and disappear; but, below the surface, in the depths of the liquid—(one centimetre of septic liquid may in this case be called depths), "the vibriones are protected against the action of oxygen by their brothers, who are dying above

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them, and they continue for a time to multiply by division; they afterwards produce germs or spores, the filiform vibrones themselves being gradually reabsorbed. Instead of a quantity of moving threads, the length of which often extends beyond the field of the microscope, nothing is seen but a dust of isolated, shiny specks, sometimes surrounded by a sort of amorphous gangue hardly visible. Here then is the septic dust, living the latent life of germs, no longer fearing the destructive action of oxygen, and we are now prepared to understand what seemed at first so obscure: the sowing of septic dust into putrescible liquids by the surrounding atmosphere, and the permanence of putrid diseases on the surface of the earth."

Pasteur continued from this to open a parenthesis on diseases "transmissible, contagious, infectious, of which the cause resides essentially and solely in the presence of microscopic organisms. It is the proof that, for a certain number of diseases, we must for ever abandon the ideas of spontaneous virulence, of contagious and infectious elements suddenly produced within the bodies of men or of animals and originating diseases afterwards propagated under identical shapes; all those opinions fatal to medical progress and which are engendered by the gratuitous hypotheses of the spontaneous generation of albuminoid-ferment materia, of hemiorganism, of archebiosis, and many other conceptions not founded on observation."

Pasteur recommended the following experiment to surgeons. After cutting a fissure into a leg of mutton, by means of a bistoury, he introduced a drop of septic vibrio culture; the vibrio immediately did its work. "The meat under those conditions becomes quite gangrened, green on its surface, swollen with gases, and is easily crushed into a disgusting, sanious pulp." And addressing the surgeons present at the meeting: "The water, the sponge, the charpie

with which you wash or dress a wound, lay on its surface germs which, as you see, have an extreme facility of propagating within the tissues, and which would infallibly bring about the death of the patients within a very short time if life in their limbs did not oppose the multiplication of germs. But how often, alas, is that vital resistance powerless! how often do the patient's constitution, his weakness, his moral condition, the unhealthy dressings, oppose but an insufficient barrier to the invasion of the Infinitesimally Small with which you have covered the injured part! If I had the honour of being a surgeon, convinced as I am of the dangers caused by the germs of microbes scattered on the surface of every object, particularly in the hospitals, not only would I use absolutely clean instruments, but, after cleansing my hands with the greatest care and putting them quickly through a flame, (an easy thing to do with a little practice), I would only make use of charpie, bandages, and sponges which had previously been raised to a heat of 130°C . to 150°C .; I would only employ water which had been heated to a temperature of 110° to 120°C . All that is easy in practice, and, in that way, I should still have to fear the germs suspended in the atmosphere surrounding the bed of the patient; but observation shows us every day that the number of those germs is almost insignificant compared to that of those which lie scattered on the surface of objects, or in the clearest ordinary water."

He came down to the smallest details, seeing in each one an application of the rigorous principles which were to transform Surgery, Medicine and Hygiene. How many human lives have since then been saved by the dual development of that one method! The defence against microbes afforded by the substances which kill them or arrest their development, such as carbolic acid, sublimate, iodoform, salol, etc., etc., constitutes *antisepsis*; then the

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other progress, born of the first, the obstacle opposed to the arrival of the microbes and germs by complete disinfection, absolute cleanliness of the instruments and hands, of all which is to come into contact with the patient ; in one word, *asepsis*.

It might have been prophesied at that date that Pasteur's surprised delight at seeing his name gratefully inscribed on the great Italian establishment of sericulture would one day be surpassed by his happiness in living to see realized some of the progress and benefits due to him, his name invoked in all operating theatres, engraved over the doors of medical and surgical wards, and a new era inaugurated.

A presentiment of the future deliverance of Humanity from those redoubtable microscopic foes gave Pasteur a fever for work, a thirst for new research, and an immense hope. But once again he constrained himself, refrained from throwing himself into varied studies, and, continuing what he had begun, reverted to his studies on splenic fever.

The neighbourhood of Chartres being most afflicted, the Minister of Agriculture, anticipating the wish of the Conseil Général of the department of Eure et Loir, had entrusted Pasteur with the mission of studying the causes of so-called spontaneous charbon, that which bursts out unexpectedly in a flock, and of seeking for curative and preventive means of opposing the evil. Thirty-six years earlier, the learned veterinary surgeon, Delafond, had been sent to seek, particularly in the Beauce country, the causes of the charbon disease. Bouley, a great reader, said that there was no contrast more instructive than that which could be seen between the reasoning method followed by Delafond, and the experimental method practised by Pasteur. It was in 1842 that Delafond received from M. Cunin Gridaine, then Minister of Agriculture, the mission of "going to study that malady on the spot, to seek for its causes, and to

examine particularly whether those causes did not reside in the mode of culture in use in that part of the country." Delafond arrived in the Beauce, and, having seen that the disease struck the strongest sheep, it occurred to him that it came from "an excess of blood circulating in the vessels." He concluded from that that there might be a correlation between the rich blood of the Beauce sheep and the rich nitrogenous pasture of their food.

He therefore advised the cultivators to diminish the daily ration; and he was encouraged in his views by noting that the frequency of the disease diminished in poor, damp, or sandy soils.

Bouley, in order to show up Delafond's efforts to make facts accord with his reasoning, added that to explain "a disease, of which the essence is general plethora, becoming contagious and expressing itself by charbon symptoms in man," Delafond had imagined that the atmosphere of the pens, into which the animals were crowded, was laden with evil gases and putrefying emanations which produced an alteration of the blood "due at the same time to a slow asphyxia and to the introduction through the lungs of septic elements into the blood."

It would have been but justice to recall other researches connected with Delafond's name. In 1863, Delafond had collected some blood infected with charbon, and, at a time when such experiments had hardly been thought of, he had attempted some experiments on the development of the bacteridium, under a watch glass, at the normal blood temperature. He had seen the little rods grow into filaments, and compared them to a "very remarkable mycelium." "I have vainly tried to see the mechanism of fructification," added Delafond, "but I hope I still may." Death struck down Delafond before he could continue his work.

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In 1869 a scientific congress was held at Chartres; one of the questions examined being this: "What has been done to oppose splenic fever in sheep?" A veterinary surgeon enumerated the causes which contributed, according to him, to produce and augment mortality by splenic fever: bad hygienic conditions; tainted food, musty or cryptogamized; heated and vitiated air in the crowded pens, full of putrid manure; paludic miasma or effluvia; damp soil flooded by storms, etc., etc. A well known veterinary surgeon, M. Boutet, saw no other means to preserve what remained of a stricken flock but to take it to another soil, which, in contradiction with his colleague, he thought should be chosen cool and damp. No conclusion could be drawn. The disastrous loss caused by splenic fever in the Beauce alone was terrible; it was said to have reached 20,000,000 francs in some particularly bad years. The migration of the tainted flock seemed the only remedy, but it was difficult in practice and offered danger to other flocks, as carcasses of dead sheep were wont to mark the road that had been followed.

Pasteur, starting from the fact that the charbon disease is produced by the bacteridium, proposed to prove that, in a department like that of Eure et Loir, the disease maintained itself by itself. When an animal dies of splenic fever in a field, it is frequently buried in the very spot where it fell; thus a focus of contagion is created, due to the anthrax spores mixed with the earth where other flocks are brought to graze. Those germs, thought Pasteur, are probably like the germs of the flachery vibrio, which survive from one year to another and transmit the disease. He proposed to study the disease on the spot.

It almost always happened that, when he was most anxious to give himself up entirely to the study of a problem, some new discussion was started to hinder him.

He had certainly thought that the experimental power of giving anthrax to hens had been fully demonstrated, and that that question was dead, as dead as the inoculated and immersed hen.

Colin, however, returned to the subject, and at an Academy meeting of July 9 said somewhat insolently, "I wish we could have seen the bacteridia of that dead hen which M. Pasteur showed us without taking it out of its cage, and which he took away intact instead of making us witness the necropsy and microscopical examination." "I will take no notice," said Pasteur at the following meeting, "of the malevolent insinuations contained in that sentence, and only consider M. Colin's desire to hold in his hands the body of a hen dead of anthrax, full of bacteridia. I will, therefore, ask M. Colin if he will accept such a hen under the following condition: the necropsy and microscopic examination shall be made by himself, in my presence, and in that of one of our colleagues of this Academy, designated by himself or by this Academy, and an official report shall be drawn up and signed by the persons present. So shall it be well and duly stated that M. Colin's conclusions, in his paper of May 14, are null and void. The Academy will understand my insistence in rejecting M. Colin's superficial contradictions.

"I say it here with no sham modesty: I have always considered that my only right to a seat in this place is that given me by your great kindness, for I have no medical or veterinary knowledge. I therefore consider that I must be more scrupulously exact than any one else in the presentations which I have the honour to make to you; I should promptly lose all credit if I brought you erroneous or merely doubtful facts. If ever I am mistaken, a thing which may happen to the most scrupulous, it is because my good faith has been greatly surprised.

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"On the other hand, I have come amongst you with a programme to follow which demands accuracy at every step. I can tell you my programme in two words: I have sought for twenty years, and I am still seeking, spontaneous generation properly so-called.

"If God permit, I shall seek for twenty years and more the spontaneous generation of transmissible diseases.

"In these difficult researches, whilst sternly deprecating frivolous contradiction, I only feel esteem and gratitude towards those who may warn me if I should be in error."

The Academy decided that the necropsy and microscopic examination of the dead hen which Pasteur was to bring to Colin should take place in the presence of a Commission composed of Pasteur, Colin, Davaine, Bouley, and Vulpian. This Commission met on the following Saturday, July 20, in the Council Chamber of the Academy of Medicine. M. Armand Moreau, a member of the Academy, joined the five members present, partly out of curiosity, and partly because he had special reasons for wishing to speak to Pasteur after the meeting.

Three hens were lying on the table, all of them dead. The first one had been inoculated under the thorax with five drops of yeast water slightly alkalized, which had been given as a nutritive medium to some bacteridia anthracis; the hen had been placed in a bath at 25° C., and had died within twenty-two hours. The second one, inoculated with ten drops of a culture liquid, had been placed in a warmer bath, 30° C., and had died in thirty-six hours. The third hen, also inoculated and immersed, had died in forty-six hours.

Besides those three dead hens, there was a living one which had been inoculated in the same way as the first hen. This one had remained for forty-three hours with one-third of its body immersed in a barrel of water. When it was seen

in the laboratory that its temperature had gone down to 36° C., that it was incapable of eating and seemed very ill, it was taken out of the tub that very Saturday morning, and warmed in a stove at 42° C. It was now getting better, though still weak, and gave signs of an excellent appetite before leaving the Academy council chamber.

The third hen, which had been inoculated with ten drops, was dissected then and there. Bouley, after noting a serous infiltration at the inoculation focus, showed to the judges sitting in this room, thus suddenly turned into a testing laboratory, numerous bacteridia scattered throughout every part of the hen.

"After those ascertained results," wrote Bouley, who drew up the report, "M. Colin declared that it was useless to proceed to the necropsy of the two other hens, that which had just been made leaving no doubt of the presence of bacilli anthracis in the blood of a hen inoculated with charbon and then placed under the conditions designated by M. Pasteur as making inoculation efficacious."

"The hen No. 2 has been given up to M. Colin to be used for any examination or experiment which he might like to try at Alfort."

"Signed : G. Colin, H. Bouley, C. Davaine, L. Pasteur, A. Vulpian."

"This is a precious autograph, headed as it is by M. Colin's signature!" gaily said Bouley. But Pasteur, pleased as he was with this conclusion, which put an end to all discussion on that particular point, was already turning his thoughts into another channel. The Academician who had joined the members of the Commission was showing him a number of the *Revue Scientifique* which had appeared that morning, and which contained an article of much interest to Pasteur.

In October, 1877, Claude Bernard, staying for the last

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time at St. Julien, near Villefranche, had begun some experiments on fermentations. He had continued them on his return to Paris, alone, in the study which was above his laboratory at the Collège de France.

When Paul Bert, his favourite pupil, M. d'Arsonval, his curator, M. Dastre, a former pupil, and M. Armand Moreau, his friend, came to see him, he said to them in short, enigmatical sentences, with no comment or experimental demonstration, that he had done some good work during the vacation. "Pasteur will have to look out . . . Pasteur has only seen one side of the question . . . I make alcohol without cells . . . There is no life without air . . ."

Bernard's and Pasteur's seats at the Academy of Sciences were next to each other, and they usually enjoyed interchanging ideas. Claude Bernard had come to the November and December sittings, but, with a reticence to which he had not accustomed Pasteur, he had made no allusion to his October experiments. In January, 1878, he became seriously ill; in his conversations with M. d'Arsonval, who was affectionately nursing him, Claude Bernard talked of his next lecture at the Museum, and said that he would discuss his ideas with Pasteur before handling the subject of fermentations. At the end of January M. d'Arsonval alluded to these incomplete revelations. "It is all in my head," said Claude Bernard, "but I am too tired to explain it to you." He made the same weary answer two or three days before his death. When he succumbed, on February 10, 1878, Paul Bert, M. d'Arsonval and M. Dastre thought it their duty to ascertain whether their master had left any notes relative to the work which embodied his last thoughts. M. d'Arsonval, after a few days' search, discovered some notes, carefully hidden in a cabinet in Claude Bernard's bedroom; they were all dated from the 1st to the 20th of

October, 1877; of November and December, there was no record. Had he then not continued his experiments during that period? Paul Bert thought that these notes did not represent a work, not even a sketch, but a sort of programme. "It was all condensed into a series of masterly conclusions," said Paul Bert, "which evidenced certitude, but there were no means of discussing through which channel that certitude had come to his prudent and powerful mind." What should be done with those notes? Claude Bernard's three followers decided to publish them. "We must," said Paul Bert, "while telling the conditions under which the manuscript was found, give it its character of incomplete notes, of confidences made to itself by a great mind seeking its way, and marking its road indiscriminately with facts and with hypotheses in order to arrive at that feeling of certainty which, in the mind of a man of genius, often precedes proof." M. Berthelot, to whom the manuscript was brought, presented these notes to the readers of the *Revue Scientifique*. He pointed to their character, too abbreviated to conclude with a rigorous demonstration, but he explained that several friends and pupils of Claude Bernard had "thought that there would be some interest for Science in preserving the trace of the last subjects of thought, however incomplete, of that great mind."

Pasteur, after the experiment at the Académie de Médecine, hurried back to his laboratory and read with avidity those last notes of Claude Bernard. Were they a precious find, explaining the secrets Claude Bernard had hinted at? "Should I," said Pasteur, "have to defend my work, this time against that colleague and friend for whom I professed deep admiration, or should I come across unexpected revelations, weakening and discrediting the results I thought I had definitely established?"

His reading reassured him on that point, but saddened

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him on the other hand. Since Claude Bernard had neither desired nor even authorized the publication of those notes, why, said Pasteur, were they not accompanied by an experimental commentary? Thus Claude Bernard would have been credited with what was good in his MSS., and he would not have been held responsible for what was incomplete or defective.

"As for me, personally," wrote Pasteur in the first pages of his *Critical Examination of a Posthumous Work of Claude Bernard on Fermentation*, "I found myself cruelly puzzled; had I the right to consider Claude Bernard's MS. as the expression of his thought, and was I free to criticize it thoroughly?" The table of contents and headings of chapters in Claude Bernard's incomplete MS. condemned Pasteur's work on alcoholic fermentation. The non-existence of life without air; the ferment *not* originated by exterior germs; alcohol formed by a soluble ferment outside life . . . such were Claude Bernard's conclusions. "If Claude Bernard was convinced," thought Pasteur, "that he held the key to the masterly conclusions with which he ended his manuscript, what could have been his motive in withholding it from me? I looked back upon the many marks of kindly affection which he had given me since I entered on a scientific career, and I came to the conclusion that the notes left by Bernard were but a programme of studies, that he had tackled the subject, and that, following in this a method habitual to him, he had, the better to discover the truth, formed the intention of trying experiments which might contradict my opinions and results."

Pasteur, much perplexed, resolved to put the case before his colleagues, and did so two days later. He spoke of Bernard's silence, his abstention from any allusion at their weekly meetings. "It seems to me almost impossible," he

said, "and I wonder that those who are publishing these notes have not perceived that it is a very delicate thing to take upon oneself, with no authorization from the author, the making public of private notebooks! Which of us would care to think it might be done to him! . . . Bernard must have put before himself that leading idea, that I was in the wrong on every point, and taken that method of preparing the subject he intended to study." Such was also the opinion of those who remembered that Claude Bernard's advice invariably was that every theory should be doubted at first and only trusted when found capable of resisting objections and attacks.

"If then, in the intimacy of conversation with his friends and the yet more intimate secret of notes put down on paper and carefully put away, Claude Bernard develops a plan of research with a view to judging of a theory—if he imagines experiments—he is resolved not to speak about it until those experiments have been clearly checked; we should therefore not take from his notes the most expressly formulated propositions without reminding ourselves that all that was but a project, and that he meant to go once again through the experiments he had already made."

Pasteur declared himself ready to answer any one who would defend those experiments which he looked upon as doubtful, erroneous, or wrongly interpreted. "In the opposite case," he said, "out of respect for Claude Bernard's memory, I will repeat his experiments before discussing them."

Some Academicians discoursed on these notes as on simple suggestions and advised Pasteur to continue his studies without allowing himself to be delayed by mere control experiments. Others considered these notes as the expression of Claude Bernard's thought. "That opinion," said Pasteur—man of sentiment as he was—"that opinion,

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however, does not explain the enigma of his silence towards me. But why should I look for that explanation elsewhere than in my intimate knowledge of his fine character? Was not his silence a new proof of his kindness, and one of the effects of our mutual esteem? Since he thought that he held in his hands a proof that the interpretation I had given to my experiments was fallacious, did he not simply wish to wait to inform me of it until the time when he thought himself ready for a definite statement? I prefer to attribute high motives to my friend's actions, and, in my opinion, the surprise caused in me by his reserve towards the one colleague whom his work most interested should give way in my heart to feelings of pious gratitude. However, Bernard would have been the first to remind me that scientific truth soars above the proprieties of friendship, and that my duty lies in discussing views and opinions in my turn with full liberty."

Pasteur having made this communication to the Academy on July 22, hastily ordered three glass houses, which he intended to take with him into the Jura, "where I possess, he told his colleagues, "a vineyard occupying some thirty or forty square yards."

Two observations expounded in a chapter of his *Studies on Beer* tend to establish that yeast can only appear about the time when grapes ripen, and that it disappears in the winter only to show itself again at the end of the summer." Therefore "germs of yeast do not yet exist on green grapes." "We are," he added, "at an epoch in the year when, by reason of the lateness of vegetation due to a cold and rainy season, grapes are still in the green stage in the vineyards of Arbois. If I choose this moment to enclose some vines in almost hermetically closed glass houses, I shall have in October during the vintage some vines bearing ripe grapes without the exterior germs of wine yeast.

Those grapes, crushed with precautions which will not allow of the introduction of yeast germs, will neither ferment nor produce wine. I shall give myself the pleasure of bringing some back to Paris, to present them to the Academy and to offer a few bunches to those of our colleagues who are still able to believe in the spontaneous generation of yeast."

In the midst of the agitation caused by that posthumous work some said, or only insinuated, that if Pasteur was announcing new researches on the subject, it was because he felt that his work was threatened.

"I will not accept such an interpretation of my conduct," he wrote to J. B. Dumas on August 4, 1878, at the very time when he was starting for the Jura; I have clearly explained this in my notice of July 22, when I said I would make new experiments solely from respect to Bernard's memory."

As soon as Pasteur's glass houses arrived, they were put up in the little vineyard he possessed, two kilometres from Arbois. While they were being put together, he examined whether the yeast germs were really absent from the bunches of green grapes; he had the satisfaction of seeing that it was so, and that the particular branches which were about to be placed under glass did not bear a trace of yeast germs. Still, fearing that the closing of the glass might be insufficient and that there might thus be a danger of germs, he took the precaution, "while leaving some bunches free, of wrapping a few on each plant with cotton wool previously heated to 150° C."

He then returned to Paris and his studies on anthrax, whilst patiently waiting for the ripening of his grapes.

Besides M. Chamberland, Pasteur had enrolled M. Roux, the young man who was so desirous of taking part in the work at the laboratory. He and M. Chamberland were to

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settle down at Chartres in the middle of the summer. A recent student of the Alfort Veterinary School, M. Vinsot, joined them at his own request. M. Roux has told of those days in a paper on *Pasteur's Medical Work*:

"Our guide was M. Boutet, who had unrivalled knowledge of the splenic fever country, and we sometimes met M. Toussaint, who was studying the same subject as we were. We have kept a pleasant memory of that campaign against charbon in the Chartres neighbourhood. Early in the morning, we would visit the sheepfolds scattered on that wide plateau of the Beauce, dazzling with the splendour of the August sunshine; then necropsies took place in M. Rabourdin's knacker's yard or in the farmyards. In the afternoon, we edited our experiment notebooks, wrote to Pasteur, and arranged for new experiments. The day was well filled, and how interesting and salutary was that bacteriology practised in the open air!"

"On the days when Pasteur came to Chartres, we did not linger over our lunch at the Hôtel de France; we drove off to St. Germain, where M. Maunoury had kindly put his farm and flocks at our disposal. During the drive we talked of the week's work and of what remained to be done.

"As soon as Pasteur left the carriage he hurried to the folds. Standing motionless by the gate, he would gaze at the lots which were being experimented upon, with a careful attention which nothing escaped; he would spend hours watching one sheep which seemed to him to be sickening. We had to remind him of the time and to point out to him that the towers of Chartres Cathedral were beginning to disappear in the falling darkness before we could prevail upon him to come away. He questioned farmers and their servants, giving much credit to the opinions of shepherds, who, on account of their solitary life, give their

whole attention to their flocks and often become sagacious observers."

When again at Arbois, on September 17, Pasteur began to write to the Minister of Agriculture a note on the practical ideas suggested by this first campaign. A few sheep, bought near Chartres and gathered in a fold, had received, amongst the armfuls of forage offered them, a few anthrax spores. Nothing had been easier than to bring these from the laboratory, in a liquid culture of bacteria, and to scatter them on the field where the little flock grazed. The first meals did not give good scientific results, death was not easily provoked. But when the experimental menu was completed by prickly plants, likely to wound the sheep on their tongue or in their pharynx, such, for instance, as thistles or ears of barley, the mortality began. It was perhaps not as considerable as might have been wished for demonstration purposes, but nevertheless it was sufficient to explain how charbon could declare itself, for necropsy showed the characteristic lesions of the so-called spontaneous splenic fever. It was also to be concluded therefrom that the evil begins in the mouth, or at the back of the throat, supervening on meals of infected food, alone or mixed with prickly plants likely to cause abrasion.

It was therefore necessary, in a department like that of Eure et Loir, which must be full of anthrax germs,—particularly on the surface of the graves containing carcasses of animals which had fallen victims to the disease,—that sheep farmers should keep from the food of their animals plants such as thistles, ears of barley, and sharp pieces of straw; for the least scratch, usually harmless to sheep, became dangerous through the possible introduction of the germs of the disease.

"It would also be necessary," wrote Pasteur, "to avoid all

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probable diffusion of charbon germs through the carcasses of animals dying of that disease, for it is likely that the department of Eure et Loir contains those germs in greater quantities than the other departments; splenic fever having long been established there, it always goes on, dead animals not being disposed of so as to destroy all germs of ulterior contagion."

After finishing this report, Pasteur went to his little vineyard on the Besançon road, where he met with a disappointment; his precious grapes had not ripened, all the strength of the plant seemed to have gone to the wood and leaves. But the grapes had their turn at the end of September and in October, those bunches that were swathed in cotton wool as well as those which had remained free under the glass; there was a great difference of colour between them, the former being very pale. Pasteur placed grapes from the two series in distinct tubes. On October 10, he compared the grapes of the glass houses, free or swathed, with the neighbouring open-air grapes. "The result was beyond my expectations; the tubes of open-air grapes fermented with grape yeast after a thirty-six or forty-eight hours' sojourn in a stove from 25° C. to 30°; not one, on the contrary, of the numerous tubes of grapes swathed in cotton wool entered into alcoholic fermentation, neither did any of the tubes containing grapes ripened free under glass. It was the experiment described in my *Studies on Beer*. On the following days I repeated these experiments with the same results." He went on to another experiment. He cut some of the swathed bunches and hung them to the vines grown in the open air, thinking that those bunches—exactly similar to those which he had found incapable of fermentation—would thus get covered with the germs of alcoholic ferments, as did the bunches

grown in the open air and their wood. After that, the bunches taken from under the glass and submitted to the usual régime would ferment under the influence of the germs which they would receive as well as the others; this was exactly what happened.

The difficulty now was to bring to the Académie des Sciences these branches bearing swathed bunches of grapes; in order to avoid the least contact to the grapes, these vine plants, as precious as the rarest orchids, had to be held upright all the way from Arbois to Paris. Pasteur came back to Paris in a coupé carriage on the express train, accompanied by his wife and daughter, who took it in turns to carry the vines. At last, they arrived safely at the Ecole Normale, and from the Ecole Normale to the Institute, and Pasteur had the pleasure of bringing his grapes to his colleagues as he had brought his hens. "If you crush them while in contact with pure air," he said, "I defy you to see them ferment." A long discussion then ensued with M. Berthelot, which was prolonged until February, 1879.

"It is a characteristic of exalted minds," wrote M. Roux, "to put passion into ideas. . . . For Pasteur, the alcoholic fermentation was correlative with the life of the ferment; for Bernard and M. Berthelot, it was a chemical action like any other, and could be accomplished without the participation of living cells." "In alcoholic fermentation," said M. Berthelot, "a soluble alcoholic ferment may be produced, which perhaps consumes itself as its production goes on."

M. Roux had seen Pasteur try to "extract the soluble alcoholic ferment from yeast cells by crushing them in a mortar, by freezing them until they burst, or by putting them into concentrated saline solutions, in order to force by osmose the succus to leave its envelope." Pasteur confessed

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that his efforts were vain. In a communication to the Académie des Sciences on December 30, 1878, he said—

“It ever is an enigma to me that it should be believed that the discovery of soluble ferments in fermentations properly so called, or of the formation of alcohol by means of sugar, independently of cells would hamper me. It is true—I own it without hesitation, and I am ready to explain myself more lengthily if desired—that at present I neither see the necessity for the existence of those ferments, nor the usefulness of their action in this order of fermentations. Why should actions of *diastase*, which are but phenomena of hydration, be confused with those of organized ferments, or vice versa? But I do not see that the presence of those soluble substances, if it were ascertained, could change in any way the conclusions drawn from my labours, and even less so if alcohol were formed by electrolysis.

“They agree with me who admit:

“Firstly. That fermentations, properly so called, offer as an essential condition the presence of microscopic organisms.

“Secondly. That those organisms have not a spontaneous origin.

“Thirdly. That the life of every organism which can exist away from free oxygen is suddenly concomitant with acts of fermentation; and that it is so with every cell which continues to produce chemical action without the contact of oxygen.”

When Pasteur related this discussion, and formed of it an appendix to his book: *Critical Examination of a Posthumous Work of Claude Bernard on Fermentations*, his painful feelings in opposing a friend who was no more were so clearly evidenced that Sainte Claire Deville wrote to him (June 9, 1879): “My dear Pasteur, I read a few passages of your

new book yesterday to a small party of professors and savants. We all were much moved by the expressions with which you praise our dear Bernard, and by your feelings of friendship and pure fraternity."

Sainte Claire Deville often spoke of his admiration for Pasteur's precision of thought, his forcible speech, the clearness of his writings. As for J. B. Dumas, he called the attention of his colleagues at the Académie Française to certain pages of that *Critical Examination*. Though unaccustomed to those particular subjects, they could not but be struck by the sagacity and ingenuity of Pasteur's researches, and by the eloquence inspired by his genius. A propos of those ferment germs, which turn grape juice into wine, and from which he had preserved his swathed bunches, Pasteur wrote—

" What meditations are induced by those results ! It is impossible not to observe that, the further we penetrate into the experimental study of germs, the more we perceive sudden lights and clear ideas on the knowledge of the causes of contagious diseases ! Is it not worthy of attention that, in that Arbois vineyard (and it would be true of the million *hectares* of vineyards of all the countries in the world), there should not have been, at the time when I made the aforesaid experiments, one single particle of earth which would not have been capable of provoking fermentation by a grape yeast, and that, on the other hand, the earth of the glass houses I have mentioned should have been powerless to fulfil that office ? And why ? Because, at a given moment, I covered that earth with some glass. The death, if I may so express it, of a bunch of grapes thrown at that time on any vineyard, would infallibly have occurred through the *saccharomyces* parasites of which I speak ; that kind of death would have been impossible, on the contrary, on the little space enclosed by my glass

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houses. Those few cubic yards of air, those few square yards of soil, were there, in the midst of a universal possible contagion, and they were safe from it."

And suddenly looking beyond those questions of yeast and vintage, towards the germs of disease and of death : "Is it not permissible to believe, by analogy, that a day will come when easily applied preventive measures will arrest those scourges which suddenly desolate and terrify populations ; such as the fearful disease (yellow fever) which has recently invaded Senegal and the valley of the Mississippi, or that other (bubonic plague), yet more terrible perhaps, which has ravaged the banks of the Volga."

Pasteur, with his quick answers, his tenacious refutations, was looked upon as a great fighter by his colleagues at the Academy, but in the laboratory, while seeking Claude Bernard's soluble ferment, he tackled subjects from which he drew conclusions which were amazing to physicians.

A worker in the laboratory had had a series of furuncles. Pasteur, whose proverb was " Seek the microbe," asked himself whether the pus of furuncles might not have an organism, which, carried to and fro,—for it may be said that a furuncle never comes alone—would explain the centre of inflammation and the recurrence of the furuncles. After abstracting—with the usual purity precautions—some pus from three successive furuncles, he found in some sterilized broth, a microbe, formed of little rounded specks which clustered to the sides of the culture vessel. The same was observed on a man whom Dr. Maurice Raynaud, interested in those researches on furuncles, had sent to the laboratory, and afterwards on a female patient of the Lariboisière Hospital, whose back was covered with furuncles. Later on, Pasteur, taken by Dr. Lannelongue to the Trousseau Hospital, where a little girl was about to be operated on for that disease of the bones and marrow called *osteomyelitis*,

gathered a few drops of pus from the inside and the outside of the bone, and again found clusters of microbes. Sown into a culture liquid, this microbe seemed so identical with the furuncle organism that "it might be affirmed at first sight," said Pasteur, "that osteomyelitis is the furuncle of bones."

The hospital now took as much place in Pasteur's life as the laboratory. "Chamberland and I assisted him in those studies," writes M. Roux. "It was to the Hôpital Cochin or to the Maternité that we went most frequently, taking our culture tubes and sterilized pipets into the wards or operating theatres. No one knows what feelings of repulsion Pasteur had to overcome before visiting patients and witnessing post-mortem examinations. His sensibility was extreme, and he suffered morally and physically from the pains of others; the cut of the bistoury opening an abscess made him wince as if he himself had received it. The sight of corpses, the sad business of necropsies, caused him real disgust; we have often seen him go home ill from those operating theatres. But his love of science, his desire for truth were the stronger; he returned the next day."

He was highly interested in the study of puerperal fever which was still enveloped in profound darkness. Might not the application of his theories to the progress of surgery be realized in obstetrics? Could not those epidemics be arrested which passed like scourges over lying-in hospitals? It was still remembered with horror how, in the Paris Maternity Hospital, between April 1st and May 10, 1856, 64 fatalities had taken place out of 347 confinements. The hospital had to be closed, and the survivors took refuge at the Lariboisière Hospital, where they nearly all succumbed, pursued, it was thought, by the epidemic.

Dr. Tarnier, a student residing at the Maternité during that disastrous time, related afterwards how the ignorance

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of the causes of puerperal fever was such that he was sometimes called away, by one of his chiefs, from some post-mortem business, to assist in the maternity wards; nobody being struck by the thought of the infection which might thus be carried from the theatre to the bed of the patient.

The discussion which arose in 1858 at the Académie de Médecine lasted four months, and hypotheses of all kinds were brought forward. Trousseau alone showed some prescience of the future by noticing an analogy between infectious surgical accidents and infectious puerperal accidents; the idea of a ferment even occurred to him. Years passed; women of the lower classes looked upon the Maternité as the vestibule of death. In 1864, 310 deaths occurred out of 1,350 confinement cases; in 1865, the hospital had to be closed. Works of cleansing and improvements gave rise to a hope that the "epidemic genius" might be driven away. "But, at the very beginning of 1866," wrote Dr. Trélat, then surgeon-in-chief at the Maternité, "the sanitary condition seemed perturbed, the mortality rose in January, and in February we were overwhelmed." Twenty-eight deaths had occurred out of 103 cases.

Trélat enumerated various causes, bad ventilation, neighbouring wards, etc., but where was the origin of the evil?

"Under the influence of causes which escape us," wrote M. Léon Lefort about that time, "puerperal fever develops in a recently delivered woman; she becomes a centre of infection, and, if that infection is freely exercised, the epidemic is constituted."

Tarnier, who took Trélat's place at the Maternité, in 1867, had been for eleven years so convinced of the infectious nature of puerperal fever that he thought but of arresting the evil by every possible means of defence, the first of which seemed to him isolation of the patients.

In 1874, Dr. Budin, then walking the hospitals, had noted in Edinburgh the improvement due to antisepsis, thanks to Lister. Three or four years later, in 1877 and 1878, after having seen that, in the various maternity hospitals of Holland, Germany, Austria, Russia and Denmark, antisepsis was practised with success, he brought his impressions with him to Paris. Tarnier hastened to employ carbolic acid at the Maternité with excellent results, and his assistant, M. Bar, tried sublimate. While that new period of victory over fatal cases was beginning, Pasteur came to the Académie de Médecine, having found, in certain puerperal infections, a microbe in the shape of a chain or chaplet, which lent itself very well to culture.

"Pasteur," wrote M. Roux, "does not hesitate to declare that that microscopic organism is the most frequent cause of infection in recently delivered women. One day, in a discussion on puerperal fever at the Academy, one of his most weighty colleagues was eloquently enlarging upon the causes of epidemics in lying-in-hospitals; Pasteur interrupted him from his place. 'None of those things cause the epidemic; it is the nursing and medical staff who carry the microbe from an infected woman to a healthy one.' And as the orator replied that he feared that microbe would never be found, Pasteur went to the blackboard and drew a diagram of the chain-like organism, saying: 'There, that is what it is like!' His conviction was so deep that he could not help expressing it forcibly. It would be impossible now to picture the state of surprise and stupefaction into which he would send the students and doctors in hospitals, when, with an assurance and simplicity almost disconcerting in a man who was entering a lying-in ward for the first time, he criticized the appliances, and declared that all the linen should be put into a sterilizing stove."

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Pasteur was not satisfied with offering advice and criticism, making for himself irreconcilable enemies amongst those who were more desirous of personal distinction than of the progress of Science. In order the better to convince those who still doubted, he affirmed that, in a badly infected patient—what he usually and sorrowfully called an *invaded* patient—he could bring the microbe into evidence by a simple pin prick on the finger tip of the unhappy woman doomed to die the next day.

"And he did so," writes M. Roux. "In spite of the tyranny of medical education which weighed down the public mind, some students were attracted, and came to the laboratory to examine more closely those matters, which allowed of such precise diagnosis and such confident prognosis."

What struggles, what efforts, were necessary before it could be instilled into every mind that a constant watch must be kept in the presence of those invisible foes, ready to invade the human body through the least scratch—that surgeons, dressers and nurses may become causes of infection and propagators of death through forgetfulness! and before the theory of germs and the all powerfulness of microbes could be put under a full light à propos of that discussion on puerperal fever!

But Pasteur was supported and inspired during that period, perhaps the most fruitful of his existence, by the prescience that those notions meant the salvation of human lives, and that mothers need no longer be torn by death from the cradle of their new-born infants.

"I shall force them to see; they will have to see!" he repeated with a holy wrath against doctors who continued to talk, from their study or at their clubs, with some scepticism, of those newly discovered little creatures, of

those ultra-microscopic parasites, trying to moderate enthusiasm and even confidence.

An experimental fact which occurred about that time was followed with interest, not only by the Académie des Sciences, but by the general public, whose attention was beginning to be awakened. A professor at the Nancy Faculty, M. Feltz, had announced to the Académie des Sciences in March, 1897, that, in the blood abstracted from a woman, who had died at the Nancy Hospital of puerperal fever, he had found motionless filaments, simple or articulated, transparent, straight or curved, which belonged, he said, to the genus *leptothrix*. Pasteur, who in his studies on puerperal fever had seen nothing of the kind, wrote to Dr. Feltz, asking him to send him a few drops of that infected blood. After receiving and examining the sample, Pasteur hastened to inform M. Feltz that that *leptothrix* was no other than the bacillus anthracis. M. Feltz, much surprised and perplexed, declared himself ready to own his error and to proclaim it if he were convinced by examining blood infected by charbon, and which, he said, he should collect wherever he could find it. Pasteur desired to save him that trouble, and offered to send him three little guinea-pigs alive, but inoculated, the one with the deceased woman's blood, the other with the bacteridia of charbon-infected blood from Chartres, the third with some charbon-infected blood from a Jura cow.

The three rodents were inoculated on May 12, at three o'clock in the afternoon, and arrived, living, at Nancy, on the morning of the thirteenth. They died on the fourteenth, in the laboratory of M. Feltz, who was thus able to observe them with particular attention until their death.

"After carefully examining the blood of the three animals after their death, I was unable," said M. Feltz, "to detect the least difference; not only the blood, but

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the internal organs, and notably the spleen, were affected in the same manner." . . . "It is a certainty to my mind," he wrote to Pasteur, "that the contaminating agent has been the same in the three cases, and that it was the bacteridium of what you call anthrax."

There was therefore no such thing as a *leptothrix puerperalis*. And it was at a distance, without having seen the patient, that Pasteur said: "That woman died of charbon." With an honourable straightforwardness, M. Feltz wrote to the Académie des Sciences relating the facts.

"It is doubly regrettable," he concluded, "that I should not have known charbon already last year, for, on the one hand, I might have diagnosed the redoubtable complication presented by the case, and, on the other hand, sought for the mode of contamination, which at present escapes me almost completely." All he had been able to find was that the woman, a charwoman, lived in a little room near a stable belonging to a horse dealer. Many animals came there; the stable might have contained diseased ones; M. Feltz had been unable to ascertain the fact. "I must end," he added, "with thanks to M. Pasteur for the great kindness he has shown me during my intercourse with him. Thanks to him, I was able to convince myself of the identity between the bacillus *anthracis* and the bacteridium found in the blood of a woman who presented all the symptoms of grave puerperal fever."

At the time when that convincing episode was taking place, other experiments equally precise were being undertaken concerning splenic fever. The question was to discover whether it would be possible to find germs of charbon in the earth of the fields which had been contaminated purposely, fourteen months before, by pouring

culture liquids over it. It seemed beyond all probability that those germs might be withdrawn and isolated from the innumerable other microbes contained in the soil. It was done, however; 500 grammes of earth were mixed with water, and infinitesimal particles of it isolated. The spore of the bacillus anthracis resists a temperature of 80° C. or 90° C., which would kill any other microbe; those particles of earth were accordingly raised to that degree of heat and then injected into some guinea-pigs, several of which died of splenic fever. It was therefore evident that flocks were exposed to infection merely by grazing over certain fields in that land of the Beauce. For it was sufficient that some infected blood should have remained on the ground, for germs of bacteridia to be found there, perhaps years later. How often was such blood spilt as a dead animal was being taken to the knacker's yard or buried on the spot! Millions of bacteridia, thus scattered on and below the surface of the soil, produced their spores, seeds of death ready to germinate.

And yet negative facts were being opposed to these positive facts, and the theory of spontaneity invoked! "It is with deep sorrow," said Pasteur at the Académie de Médecine on November 11, 1873, "that I so frequently find myself obliged to answer thoughtless contradiction; it also grieves me much to see that the medical Press speaks of these discussions in apparent ignorance of the true principles of experimental method. . . .

"That aimlessness of criticism seems explicable to me, however, by this circumstance—that Medicine and Surgery are, I think, going through a crisis, a transition. There are two opposite currents, that of the old and that of the new-born doctrine; the first, still followed by innumerable partisans, rests on the belief in the spontaneity of transmissible diseases; the second is the

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theory of germs, of the living contagium with all its legitimate consequences. . . .”

The better to point out that difference between epochs, Pasteur respectfully advised M. Bouillaud, who was taking part in the discussion, to read over Littré’s *Medicine and Physicians*, and to compare with present ideas the chapter on epidemics written in 1836, four years after the cholera which had spread terror over Paris and over France. “Poisons and venoms die out on the spot after working the evil which is special to them,” wrote Littré, “and are not reproduced in the body of the victim, but virus and miasmata are reproduced and propagated. Nothing is more obscure to physiologists than those mysterious combinations of organic elements; but there lies the dark room of sickness and of death which we must try to open.” “Among epidemic diseases,” said Littré in another passage equally noted by Pasteur, “some occupy the world and decimate nearly all parts of it, others are limited to more or less wide areas. The origin of the latter may be sought either in local circumstances of dampness, of marshy ground, of decomposing animal or vegetable matter, or in the changes which take place in men’s mode of life.”

“If I had to defend the novelty of the ideas introduced into medicine by my labours of the last twenty years,” wrote Pasteur from Arbois in September, 1879, “I should invoke the significant spirit of Littré’s words. Such was then the state of Science in 1836, and those ideas on the etiology of great epidemics were those of one of the most advanced and penetrating minds of the time. I would observe, contrarily to Littré’s opinion, that nothing proves the spontaneity of great epidemics! As we have lately seen the phylloxera, imported from America, invade Europe, so it might be that the causes of great pests were originated,

unknowingly to stricken countries, in other countries which had had fortuitous contact with the latter. Imagine a microscopic being, inhabiting some part of Africa and existing on plants, on animals, or even on men, and capable of communicating a disease to the white race; if brought to Europe by some fortuitous circumstance, it may become the occasion of an epidemic. . . .”

And, writing later, about the same passage: “Nowadays, if an article had to be written on the same subject, it would certainly be the idea of living ferments and microscopic beings and germs which would be mentioned and discussed as a cause. That is the great progress,” added Pasteur with legitimate pride, “in which my labours have had so large a share. But it is characteristic of Science and Progress that they go on opening new fields to our vision; the scientist, who is exploring the unknown, resembles the traveller who perceives further and higher summits as he reaches greater altitudes. In these days, more infectious diseases, more microscopic beings appear to the mind as things to be discovered, the discovery of which will render a wonderful account of pathological conditions and of their means of action and propagation, of self-multiplication within and destruction of the organism. The point of view is very different from Littré’s!!”

On his return to Paris, Pasteur, his mind overflowing with ideas, had felt himself impelled to speak again, to fight once more the fallacious theory of the spontaneity of transmissible diseases. He foresaw the triumph of the germ theory arising from the ruin of the old doctrines—at the price, it is true, of many efforts, many struggles, but those were of little consequence to him.

The power of his mind, the radiating gifts that he possessed, were such that his own people were more and more interested in the laboratory, every one trying day by

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day to penetrate further into Pasteur's thoughts. His family circle had widened ; his son and his daughter had married, and the two new-comers had soon been initiated into past results and recent experiments. He had, in his childhood and youth, been passionately loved by his parents and sisters, and now, in his middle age, his tenderness towards his wife and children was eagerly repaid by the love they bore him. He made happiness around him whilst he gave glory to France.

CHAPTER III

1880 1882

A NEW microbe now became the object of the same studies of culture and inoculation as the bacillus anthracis. Readers of this book may have had occasion to witness the disasters caused in a farmyard by a strange and sudden epidemic. Hens, believed to be good sitters, are found dead on their nests. Others, surrounded by their brood, allow the chicks to leave them, giving them no attention; they stand motionless in the centre of the yard, staggering under a deadly drowsiness. A young and superb cock, whose triumphant voice was yesterday heard by all the neighbours, falls into a sudden agony, his beak closed, his eyes dim, his purple comb drooping limply. Other chickens, respited till the next day, come near the dying and the dead, picking here and there grains soiled with excreta containing the deadly germs: it is chicken cholera.

An Alsatian veterinary surgeon of the name of Moritz had been the first to notice, in 1869, some "granulations" in the corpses of animals struck down by this lightning disease, which sometimes kills as many as ninety chickens out of a hundred, those who survive having probably recovered from a slight attack of the cholera. Nine years after Moritz, Perroncito, an Italian veterinary surgeon, made a sketch of the microbe, which has the appearance

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of little specks. Toussaint studied it, and demonstrated that this microbe was indeed the cause of virulence in the blood. He sent to Pasteur the head of a cock that had died of cholera. The first thing to do, after isolating the microbe, was to try successive cultures; Toussaint had used neutralized urine. This, though perfect for the culture of the bacillus anthracis, proved a bad culture medium for the microbe of chicken cholera; its multiplication soon became arrested. If sown in a small flask of yeast water, equally favourable to bacteridia, the result was worse still: the microbe disappeared in forty-eight hours.

"Is not that," said Pasteur—with the gift of comparison which made him turn each failure into food for reflection—"an image of what we observe when a microscopic organism proves to be harmless to a particular animal species? It is harmless because it does not develop within the body, or because its development does not reach the organs essential to life."

After trying other culture mediums, Pasteur found that the one which answered best was a broth of chicken gristle, neutralized with potash and sterilized by a temperature of 110° C. to 115° C.

"The facility of multiplication of the micro-organism in that culture medium is really prodigious," wrote Pasteur in a duplicate communication to the Academies of Sciences and of Medicine (February, 1880), entitled *Of Virulent Diseases, and in particular that commonly called Chicken Cholera*. "In a few hours, the most limpid broth becomes turgid and is found to be full of little articles of an extreme tenuity, slightly strangled in their middle and looking at first sight like isolated specks; they are incapable of locomotion. Within a few days, those beings, already so small, change into a multitude of specks so much smaller, that the culture liquid, which had at first become turgid, almost

milky, becomes nearly clear again, the specks being of such narrow diameter as to be impossible to measure, even approximately.

"This microbe certainly belongs to quite another group than that of the vibriones. I imagine that it will one day find a place with the still mysterious virus, when the latter are successfully cultivated, which will be soon, I hope."

Pasteur stated that the virulence of this microbe was such that the smallest drop of recent culture, on a few crumbs, was sufficient to kill a chicken. Hens fed in this way contracted the disease by their intestinal canal, an excellent culture medium for the micro-organism, and perished rapidly. Their infected excreta became a cause of contagion to the hens which shared with them the laboratory cages. Pasteur thus described one of these sick hens—

"The animal suffering from this disease is powerless, staggering; its wings droop and its bristling feathers give it the shape of a ball; an irresistible somnolence overpowers it. If its eyes are made to open, it seems to awake from a deep sleep, and death frequently supervenes after a dumb agony, before the animal has stirred from its place; sometimes there is a faint fluttering of the wings for a few seconds."

Pasteur tried the effect of this microbe on guinea-pigs which had been brought up in the laboratory, and found it but rarely mortal; in general it merely caused a sore, terminating in an abscess, at the point of inoculation. If this abscess were opened, instead of being allowed to heal of its own accord, the little microbe of chicken cholera was to be found in the pus, preserved in the abscess as it might be in a phial.

"Chickens or rabbits," remarked Pasteur, "living in the society of guinea-pigs presenting these abscesses, might

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suddenly become ill and die without any alteration being seen in the guinea-pigs' health. It would suffice for this purpose that those abscesses should open and drop some of their contents on the food of the chickens and rabbits.

"An observer witnessing those facts, and ignorant of the above-mentioned cause, would be astonished to see hens and rabbits decimated without apparent cause, and would believe in the spontaneity of the evil; for he would be far from supposing that it had its origin in the guinea-pigs, all of them in good health. How many mysteries in the history of contagions will one day be solved as simply as this !!!"

A chance, such as happens to those who have the genius of observation, was now about to mark an immense step in advance and prepare the way for a great discovery. As long as the culture flasks of chicken-cholera microbe had been sown without interruption, at twenty-four hours' interval, the virulence had remained the same; but when some hens were inoculated with an old culture, put away and forgotten a few weeks before, they were seen with surprise to become ill and then to recover. These unexpectedly refractory hens were then inoculated with some new culture, but the phenomenon of resistance recurred. What had happened? What could have attenuated the activity of the microbe? Researches proved that oxygen was the cause; and, by putting between the cultures variable intervals of days, of one, two or three months, variations of mortality were obtained, eight hens dying out of ten, then five, then only one out of ten, and at last, when, as in the first case, the culture had had time to get stale, no hens died at all, though the microbe could still be cultivated.

"Finally," said Pasteur, eagerly explaining this phenomenon, "if you take each of these attenuated cultures as a starting-point for successive and uninterrupted cul-

tures, all this series of cultures will reproduce the attenuated virulence of that which served as the starting-point ; in the same way non-virulence will reproduce non-virulence."

And, while hens who had never had chicken-cholera perished when exposed to the deadly virus, those who had undergone attenuated inoculations, and who afterwards received more than their share of the deadly virus, were affected with the disease in a benign form, a passing indisposition, sometimes even they remained perfectly well ; they had acquired immunity. Was not this fact worthy of being placed by the side of that great fact of vaccine, over which Pasteur had so often pondered and meditated ?

He now felt that he might entertain the hope of obtaining, through artificial culture, some vaccinating-virus against the virulent diseases which cause great losses to agriculture in the breeding of domestic animals, and, beyond that, the greater hope of preserving humanity from those contagious diseases which continually decimate it. This invincible hope led him to wish that he might live long enough to accomplish some new discoveries and to see his followers step into the road he had marked out.

Strong in his experimental method which enabled him to produce proofs and thus to demonstrate the truth ; able to establish the connection between a virulent and a microbian disease ; finally, ready to reproduce by culture, in several degrees of attenuation, a veritable vaccine, could he not now force those of his opponents who were acting in good faith to acknowledge the evidence of facts ? Could he not carry all attentive minds with him into the great movement which was about to replace old ideas by new and precise notions, more and more accessible ?

Pasteur enjoyed days of incomparable happiness during that period of enthusiasm, joys of the mind in its full power, joys of the heart in all its expansion ; for good was being

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done. He felt that nothing could arrest the course of his doctrine, of which he said—"The breath of Truth is carrying it towards the fruitful fields of the future." He had that intuition which makes a great poet of a great scientist. The innumerable ideas surging through his mind were like so many bees all trying to issue from the hive at the same time. So many plans and preconceived ideas only stimulated him to further researches; but, when he was once started on a road, he distrusted each step and only progressed in the train of precise, clear and irrefutable experiments.

A paper of his on the plague, dated April, 1880, illustrates his train of thought. The preceding year the Academy of Medicine had appointed a commission composed of eight members, to draw up a programme of research relative to the plague. The scourge had appeared in a village situated on the right bank of the Volga, in the district of Astrakhan. There had been one isolated case at first, followed ten days later by another death; the dread disease had then invaded and devoured the whole village, going from house to house like an inextinguishable fire; 370 deaths had occurred in a population of 1,372 inhabitants; thirty or forty people died every day. In one of those sinister moments when men forget everything in their desire to live, parents and relations had abandoned their sick and dying among the unburied dead, with 20° C. of frost!! The neighbouring villages were contaminated; but, thanks to the Russian authorities, who had established a strict sanitary cordon, the evil was successfully localized. Some doctors, meeting in Vienna, declared that that plague was no other than the Black Death of the fourteenth century, which had depopulated Europe. The old pictures and sculptures of the time, which represent Death pressing into his lugubrious gang children and old men, beggars and emperors, bear witness

to the formidable ravages of such a scourge. In France, since the epidemic at Marseilles in 1720, it seemed as if the plague were but a memory, a distant nightmare, almost a horrible fairy tale. Dr. Rochard, in a report to the Académie de Médecine, recalled how the contagion had burst out in May, 1720; a ship, having lost six men from the plague on its journey, had entered Marseilles harbour. The plague, after an insidious first phase, had raged in all its fury in July.

"Since the plague is a disease," wrote Pasteur (whose paper was a sort of programme of studies), "the cause of which is absolutely unknown, it is not illogical to suppose that it too is perhaps produced by a special microbe. All experimental research must be guided by some preconceived ideas, and it would probably be very useful to tackle the study of that disease with the belief that it is due to a parasite.

"The most decisive of all the proofs which can be invoked in favour of the possible correlation between a determined affection and the presence of a micro-organism, is that afforded by the method of cultures of organisms in a state of purity; a method by which I have solved, within the last twenty-two years, the chief difficulties relative to fermentations properly so-called; notably the important question, much debated formerly, of the correlation which exists between those fermentations and their particular ferments."

He then pointed out that if, after gathering either blood or pus immediately before or immediately after the death of a plague patient, one could succeed in discovering the micro-organism, and then in finding for that microbe an appropriate culture medium, it would be advisable to inoculate with it animals of various kinds, perhaps monkeys for preference, and to look for the lesions capable of

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establishing relations from cause to effect between that organism and the disease in mankind.

He did not hide from himself the great difficulties to be met with in experimenting; for, after discovering and isolating the organism, there is nothing to indicate *a priori* to the experimentalist an appropriate culture medium. Liquids which suit some microbes admirably are absolutely unsuitable to others. Take, for instance, the microbe of chicken-cholera, which will not develop in beer yeast; a hasty experimentalist might conclude that the chicken-cholera is not produced by a micro-organism, and that it is a spontaneous disease with unknown immediate causes. "The fallacy would be a fatal one," said Pasteur, "for in another medium, say, for instance, in chicken-broth, there would be a virulent culture."

In these researches on the plague, then, various mediums should be tried; also the character, either aërobic or an-aërobic, of the microbe should be present to the mind.

"The sterility of a culture liquid may come from the presence of air and not from its own constitution; the septic vibrio, for instance, is killed by oxygen in air. From this last circumstance it is plain that culture must be made not only in the presence of air but also in a vacuum or in the presence of pure carbonic acid gas. In the latter case, immediately after sowing the blood or humor to be tested, a vacuum must be made in the tubes, they must be sealed by means of a lamp, and left in a suitable temperature, usually between 30 C. and 40 C." Thus he prepared landmarks for the guidance of scientific research on the etiology of the plague.

Desiring as Pasteur did that the public in general should take an interest in laboratory research, he sent to his friend Nisard the number of the *Bulletin of the Académie de*

Médecine which contained a first communication on chicken-cholera, and also his paper on the plague.

"Read them if you have time," he wrote (May 3, 1880): "they may interest you, and *there should be no blanks in your education*. They will be followed by others."

"To-day, at the Institute, and to-morrow at the Académie de Médecine, I shall give a new lecture.

"Do repeat to me every criticism you hear; I much prefer them to praise, barren unless encouragement is wanted, which is certainly not my case; I have a lasting provision of faith and fire."

Nisard answered on May 7: "My very dear friend, I am almost dazed with the effort made by my ignorance to follow your ideas, and dazzled with the beauty of your discoveries on the principal point, and the number of secondary discoveries enumerated in your marvellous paper. You are right not to care for barren praise; but you would wrong those who love you if you found no pleasure in being praised by them when they have no other means of acknowledging your notes."

"I am reading the notice on chicken-cholera for the second time, and I observe that the writer is following the discoverer, and that your language becomes elevated, supple and coloured, in order to express the various aspects of the subject."

"It gives me pleasure to see the daily growth of your fame, and I am indeed proud of enjoying your friendship."

Amidst his researches on a vaccine for chicken-cholera, the etiology of splenic fever was unceasingly preoccupying Pasteur. Did the splenic germs return to the surface of the soil, and how? One day, in one of his habitual excursions with Messrs. Roux and Chamberland to the farm of St. Germain, near Chartres, he suddenly perceived an answer to that enigma. In a field recently harvested, he

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noticed a place where the colour of the soil differed a little from the neighbouring earth. He questioned M. Maunoury, the proprietor of the farm, who answered that sheep dead of anthrax had been buried there the preceding year. Pasteur drew nearer, and was interested by the mass of little earth cylinders, those little twists which earth worms deposit on the ground. Might that be, he wondered, the explanation of the origin of the germs which reappear on the surface? Might not the worms, returning from their subterranean journeys in the immediate neighbourhood of graves, bring back with them splenic spores, and thus scatter the germs so exhumed? That would again be a singular revelation, unexpected but quite simple, due to the germ theory. He wasted no time in dreaming of the possibilities opened by that preconceived idea, but, with his usual impatience to get at the truth, decided to proceed to experiment.

On his return to Paris Pasteur spoke to Bouley of this possible part of germ carriers played by earthworms, and Bouley caused some to be gathered which had appeared on the surface of pits where animals dead of splenic fever had been buried some years before. Villemin and Davaine were invited as well as Bouley to come to the laboratory and see the bodies of these worms opened; anthrax spores were found in the earth cylinders which filled their intestinal tube.

At the time when Pasteur revealed this pathogenic action of the earthworm, Darwin, in his last book, was expounding their share in agriculture. He too, with his deep attention and force of method, able to discover the hidden importance of what seemed of little account to second-rate minds, had seen how earthworms open their tunnels, and how, by turning over the soil, and by bringing

so many particles up to the surface by their "castings," they ventilate and drain the soil, and, by their incessant and continuous work, render great services to agriculture. These excellent labourers are redoubtable grave-diggers; each of those two tasks, the one beneficent and the other full of perils, was brought to light by Pasteur and Darwin, unknowingly to each other.

Pasteur had gathered earth from the pits where splenic cows had been buried in July, 1878, in the Jura. "At three different times within those two years," he said to the Académie des Sciences and to the Académie de Médecine in July, 1880, "the surface soil of those same pits has presented charbon spores." This fact had been confirmed by recent experiments on the soil of the Beauce farm; particles of earth from other parts of the field had no power of provoking splenic fever.

Pasteur, going on to practical advice, showed how grazing animals might find in certain places the germs of charbon, freed by the loosening by rain of the little castings of earth-worms. Animals are wont to choose the surface of the pits, where the soil, being richer in humus, produces thicker growth, and in so doing risk their lives, for they become infected somewhat in the same manner as in the experiments when their forage was poisoned with a few drops of splenic culture liquid. Septic germs are brought to the surface of the soil in the same way.

"Animals," said Pasteur, "should never be buried in fields intended for pasture or the growing of hay. Whenever it is possible, burying-grounds should be chosen in sandy or chalky soils, poor, dry, and unsuitable to the life of earthworms."

Pasteur, like a general with only two aides de camp, was obliged to direct the efforts of Messrs. Chamberland and Roux simultaneously in different parts of France. Some-

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times facts had to be checked which had been over-hastily announced by rash experimentalists. Thus M. Roux went, towards the end of the month of July, to an isolated property near Nancy, called Bois le Duc Farm, to ascertain whether the successive deaths of nineteen head of cattle were really, as affirmed, due to splenic fever. The water of this pasture was alleged to be contaminated; the absolute isolation of the herd seemed to exclude all idea of contagion. After collecting water and earth from various points on the estate M. Roux had returned to the laboratory with his tubes and pipets. He was much inclined to believe that there had been septicæmia and not splenic fever.

M. Chamberland was at Savagna, near Lons-le-Saulnier, where, in order to experiment on the contamination of the surface of pits, he had had a little enclosure traced out and surrounded by an open paling in a meadow where victims of splenic fever had been buried two years previously. Four sheep were folded in this enclosure. Another similar fold, also enclosing four sheep, was placed a few yards above the first one. This experiment was intended to occupy the vacation, and Pasteur meant to watch it from Arbois.

A great sorrow awaited him there. "I have just had the misfortune of losing my sister," he wrote to Nisard at the beginning of August, "to see whom (as also my parents' and children's graves) I returned yearly to Arbois. Within forty-eight hours I witnessed life, sickness, death and burial; such rapidity is terrifying. I deeply loved my sister, who, in difficult times, when modest ease even did not reign in our home, carried the heavy burden of the day and devoted herself to the little ones of whom I was one. I am now the only survivor of my paternal and maternal families."

In the first days of August, Toussaint, the young professor of the Toulouse Veterinary School, declared that he had succeeded in vaccinating sheep against splenic fever. One process of vaccination (which consisted in collecting the blood of an animal affected with charbon just before or immediately after death, defibrinating it and then passing it through a piece of linen and filtering it through ten or twelve sheets of paper) had been unsuccessful ; the bacteridia came through it all and killed instead of preserving the animal. Toussaint then had recourse to heat to kill the bacteridia : "I raised," he said, "the defibrinated blood to a heat of 55° C. for ten minutes ; the result was complete. Five sheep inoculated with three cubic cent. of that blood, and afterwards with very active charbon blood, have not felt it in the least." However, several successive inoculations had to be made.

"All ideas of holidays must be postponed ; we must set to work in Jura as well as in Paris," wrote Pasteur to his assistants. Bouley, who thought that the goal was reached, did not hide from himself the difficulties of interpretation of the alleged fact. He obtained from the Minister of Agriculture permission to try at Alfort this so-called vaccinal liquid on twenty sheep.

"Yesterday," wrote Pasteur to his son-in-law on August 13, "I went to give M. Chamberland instructions so that I may verify as soon as possible the Toussaint fact, which I will only believe when I have seen it, seen it with my own eyes. I am having twenty sheep bought, and I hope to be satisfied as to the exactitude of this really extraordinary observation in about three weeks' time. Nature may have mystified M. Toussaint, though his assertions seem to attest the existence of a very interesting fact."

Toussaint's assertion had been hasty, and Pasteur was not long in clearing up that point. The temperature of 55° C.

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prolonged for ten minutes was not sufficient to kill the bacteridia in the blood ; they were but weakened and retarded in their development ; even after fifteen minutes' exposure to the heat, there was but a numbness of the bacteridium. Whilst these experiments were being pursued in the Jura and in the laboratory of the Ecole Normale, the Alfort sheep were giving Bouley great anxiety. One died of charbon one day after inoculation, three two days later. The others were so ill that M. Nocard wanted to sacrifice one in order to proceed to immediate necropsy ; Bouley apprehended a complete disaster. But the sixteen remaining sheep recovered gradually and became ready for the counter test of charbon inoculation.

Whilst Pasteur was noting the decisive points, he heard from Bouley and from Roux at the same time, that Toussaint now obtained his vaccinal liquid, no longer by the action of heat, but by the measured action of carbolic acid on splenic fever blood. The interpretation by weakening remained the same.

"What ought we to conclude from that result?" wrote Bouley to Pasteur. "It is evident that Toussaint does not vaccinate as he thought, with a liquid destitute of bacteridia, since he gives charbon with that liquid ; but that he uses a liquid in which the power of the bacteridium is reduced by the diminished number and the attenuated activity. His vaccine must then only be charbon liquid of which the intensity of action may be weakened to the point of not being mortal to a certain number of susceptible animals receiving it. But it may be a most treacherous vaccine, in that it might be capable of recuperating its power with time. The Alfort experiment makes it probable that the vaccine tested at Toulouse and found to be harmless, had acquired in the lapse of twelve days before it was tried at Alfort, a greater intensity, because the bacteridium,

numbed for a time by carbolic acid, had had time to awaken and to swarm, in spite of the acid."

Whilst Toussaint had gone to Rheims (where sat the French Association for the Advancement of Science) to state that it was not, as he had announced, the liquid which placed the animal into conditions of relative immunity and to epitomize Bouley's interpretation, to wit, that it was a bearable charbon which he had inoculated, Pasteur wrote rather a severe note on the subject. His insisting on scrupulous accuracy in experiment sometimes made him a little hard; though the process was unreliable and the explanation inexact, Toussaint at least had the merit of having noted a condition of transitory attenuation in the bacteridium. Bouley begged Pasteur to postpone his communication out of consideration for Toussaint.

One of the sheep folded over splenic-fever pits had died on August 25, its body, full of bacteridia, proving once more the error of those who believed in the spontaneity of transmissible diseases. Pasteur informed J. B. Dumas of this, and at the same time expressed his opinion on the Toussaint fact. This letter was read at the Académie des Sciences.

"Allow me, before I finish, to tell you another secret. I have hastened, again with the assistance of Messrs. Chamberland and Roux, to verify the extraordinary facts recently announced to the Academy by M. Toussaint, professor at the Toulouse Veterinary School.

"After numerous experiments leaving no room for doubt, I can assure you that M. Toussaint's interpretations should be gone over again. Neither do I agree with M. Toussaint on the identity which he affirms as existing between acute septicæmia and chicken-cholera; those two diseases differ absolutely."

Bouley was touched by this temperate language after all

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the verifying experiments made at the Ecole Normale and in the Jura. When relating the Alfort incidents, and while expressing a hope that some vaccination against anthrax would shortly be discovered, he revealed that Pasteur had had "the delicacy of abstaining from a detailed criticism, so as to leave to M. Toussaint the care of checking his own results."

The struggle against virulent diseases was becoming more and more the capital question for Pasteur. He constantly recurred to the subject, not only in the laboratory, but in his home conversations, for he associated his family with all the preoccupations of his scientific life. Now that the oxygen of air appeared as a modifying influence on the development of a microbe in the body of animals, it seemed possible that there might be a general law applicable to every virus! What a benefit it would be if the vaccine of every virulent disease could thus be discovered! And in his thirst for research, considering that the scientific history of chicken-cholera was more advanced than that of variolic and vaccinal affections—the great fact of vaccination remaining isolated and unexplained—he hastened on his return to Paris (September, 1880) to press physicians on this special point—the relations between small-pox and vaccine. "From the point of view of physiological experimentation," he said, "the identity of the variola virus with the vaccine virus has never been demonstrated." When Jules Guérin—a born fighter, still desirous at the age of eighty to measure himself successfully with Pasteur—declared that "human vaccine is the product of animal variola (cow pox and horse pox) inoculated into man and humanised by its successive transmissions on man," Pasteur answered ironically that he might as well say, "Vaccine is—vaccine."

Those who were accustomed to speak to Pasteur with

absolute sincerity advised him not to let himself be dragged further into those discussions when his adversaries, taking words for ideas, drowned the debate in a flood of phrases. Of what good were such debates to science, since those who took the first place among veterinary surgeons, physicians and surgeons, loudly acknowledged the debt which science owed to Pasteur? Why be surprised that certain minds, deeply disturbed in their habits, their principles, their influence, should feel some difficulty, some anger even in abandoning their ideas? If it is painful to tenants to leave a house in which they have spent their youth, what must it be to break with one's whole education?

Pasteur, who allowed himself thus to be told that he lacked philosophical serenity, acknowledged this good advice with an affectionate smile. He promised to be calm; but when once in the room, his adversaries' attacks, their prejudices and insinuations, enervated and irritated him. All his promises were forgotten.

"To pretend to express the relation between human variola and vaccine by speaking but of vaccine and its relations with cow pox and horse pox, without even pronouncing the word small-pox, is mere equivocation, done on purpose to avoid the real point of the debate." Becoming excited by Guérin's antagonism, Pasteur turned some of Guérin's operating processes into ridicule with such effect that Guérin started from his place and rushed at him. The fiery octogenarian was stopped by Baron Larrey; the sitting was suspended in confusion. The following day, Guérin sent two seconds to ask for reparation by arms from Pasteur. Pasteur referred them to M. Béclard, Permanent Secretary of the Académie de Médecine, and M. Bergeron, its Annual Secretary, who were jointly responsible for the *Official Bulletin of the Academy*. "I am

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ready," said Pasteur, "having no right to act otherwise, to modify whatever the editors may consider as going beyond the rights of criticism and legitimate defence."

In deference to the opinion of Messrs. Béclard and Bergeron, Pasteur consented to terminate the quarrel by writing to the chairman of the Academy that he had no intention of offending a colleague, and that in all discussions of that kind, he never thought of anything but to defend the exactitude of his own work.

The *Journal de la Médecine et de la Chimie*, edited by M. Lucas-Championnière, said à propos of this very reasonable letter—"We, for our part, admire the meekness of M. Pasteur, who is so often described as combative and ever on the war-path. Here we have a scientist, who now and then makes short, substantial and extremely interesting communications. He is not a medical man, and yet, guided by his genius, he opens new paths across the most arduous studies of medical science. Instead of being offered the tribute of attention and admiration which he deserves, he meets with a raging opposition from some quarrelsome individuals, ever inclined to contradict after listening as little as possible. If he makes use of a scientific expression not understood by everybody, or if he uses a medical expression slightly incorrectly, then rises before him the spectre of endless speeches, intended to prove to him that all was for the best in medical science before it was assisted by the precise studies and resources of chemistry and experimentation. . . . Indeed, M. Pasteur's expression of *equivocation* seemed to us moderate!"

How many such futile incidents, such vain quarrels, traverse the life of a great man! Later on, we only see glory, apotheosis, and the statues in public places; the demi-gods seemed to have marched in triumph towards a grateful posterity. But how many obstacles and opposi-

tions are there to retard the progress of a free mind desirous of bringing his task to a successful conclusion and incited by the fruitful thought of Death, ever present to spirits preoccupied with interests of a superior order? Pasteur looked upon himself as merely a passing guest of those homes of intellect which he wished to enlarge and fortify for those who would come after him.

Confronted with the hostility, indifference and scepticism which he found in the members of the Medical Academy, he once appealed to the students who sat on the seats open to the public.

“ Young men, you who sit on those benches, and who are perhaps the hope of the medical future of the country, do not come here to seek the excitement of polemics, but come and learn Method.”

His method, as opposed to vague conceptions and *a priori* speculations, went on fortifying itself day by day. Artificial attenuation, that is, virus modified by the oxygen of air, which weakens and abates virulence; vaccination by the attenuated virus—those two immense steps in advance were announced by Pasteur at the end of 1880. But would the same process apply to the microbe of charbon? That was a great problem. The vaccine of chicken-cholera was easy to obtain; by leaving pure cultures to themselves for a time in contact with air, they soon lost their virulence. But the spores of charbon, very indifferent to atmospheric air, preserved an indefinitely prolonged virulence. After eight, ten or twelve years, spores found in the graves of victims of splenic fever were still in full virulent activity. It was therefore necessary to turn the difficulty by a culture process which would act on the filament-shaped bacteridium before the formation of spores. What may now be explained in a few words demanded long weeks of trials, tests and counter tests.

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In neutralized chicken broth, the bacteridium can no longer be cultivated at a temperature of 45° C.; it can still be cultivated easily at a temperature of 42° C. or 43° C., but the spores do not develop.

"At that extreme temperature," explains M. Chamberland, "the bacteridia yet live and reproduce themselves, but they never give any germs. Thenceforth, when trying the virulence of the phials after six, eight, ten or fifteen days, we have found exactly the same phenomena as for chicken-cholera. After eight days, for instance, our culture, which originally killed ten sheep out of ten, only kills four or five; after ten or twelve days it does not kill any; it merely communicates to animals a benignant malady which preserves them from the deadly form."

"A remarkable thing is that the bacteridia whose virulence has been attenuated may afterwards be cultivated in a temperature of 30° C. to 35° C., at which temperature they give germs presenting the same virulence as the filaments which formed them."

Bouley, who was a witness of all these facts, said, in other words, that "if that attenuated and degenerated bacteridium is translated to a culture medium in a lower temperature, favourable to its activity, it becomes once again apt to produce spores. But those spores born of weakened bacteridia, will only produce bacteridia likewise weakened in their swarming faculties."

Thus is obtained and enclosed in inalterable spores a vaccine ready to be sent to every part of the world to preserve animals by vaccination against splenic fever.

On the day when he became sure of this discovery, Pasteur, returning to his rooms from his laboratory, said to his family, with a deep emotion—"Nothing would have consoled me if this discovery, which my collaborators and I have made, had not been a French discovery."

He desired to wait a little longer before proclaiming it. Yet the cause of the evil was revealed, the mode of propagation indicated, prophylaxis made easy ; surely, enough had been achieved to move attentive minds to enthusiasm and to deserve the gratitude of sheep owners !

So thought the *Society of French Agricultors*, when it decided, on February 21, 1881, to offer to Pasteur a medal of honour. J. B. Dumas, detained at the Académie des Sciences, was unable to attend the meeting. He wrote to Bouley, who had been requested to enumerate Pasteur's principal discoveries at that large meeting—"I had desired to make public by my presence my heartfelt concurrence in your admiration for him who will never be honoured to the full measure of his merits, of his services and of his passionate devotion to truth and to our country."

On the following Monday, Bouley said to Dumas, as they were walking to the Académie des Sciences, "Your letter assures me of a small share of immortality."

"See," answered Dumas, pointing to Pasteur, who was preceding them, "there is he who will lead us both to immortality."

On that Monday, February 28, Pasteur made his celebrated communication on the vaccine of splenic fever and the whole graduated scale of virulence. The secret of those returns to virulence lay entirely in some successive cultures through the body of certain animals. If a weakened bacteridium was inoculated into a guinea-pig a few days old it was harmless; but it killed a new-born guinea-pig.

"If we then go from one new-born guinea-pig to another," said Pasteur, "by inoculation of the blood of the first to the second, from the second to a third, and so on, the virulence of the bacteridium—that is: its adaptability to development within the economy—becomes gradually

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strengthened. It becomes by degrees able to kill guinea-pigs three or four days old, then a week, a month, some years old, then sheep themselves; the bacteridium has returned to its original virulence. We may affirm, without hesitation, though we have not had the opportunity of testing the fact, that it would be capable of killing cows and horses; and it preserves that virulence indefinitely if nothing is done to attenuate it again.

"As to the microbe of chicken-cholera, when it has lost its power of action on hens, its virulence may be restored to it by applying it to small birds such as sparrows or canaries, which it kills immediately. Then by successive passages through the bodies of those animals, it gradually assumes again a virulence capable of manifesting itself anew on adult hens.

"Need I add, that, during that return to virulence, by the way, virus-vaccines can be prepared at every degree of virulence for the bacillus anthracis and for the chicken-cholera microbe.

"This question of the return to virulence is of the greatest interest for the etiology of contagious diseases."

Since charbon does not recur, said Pasteur in the course of that communication, each of the charbon microbes attenuated in the laboratory constitutes a vaccine for the superior microbe. "What therefore is easier than to find in those successive virus, virus capable of giving splenic fever to sheep, cows and horses, without making them perish, and assuring them of ulterior immunity from the deadly disease? We have practised that operation on sheep with the greatest success. When the season comes for sheep-folding in the Beauce, we will try to apply it on a large scale."

The means of doing this were given to Pasteur before long; assistance was offered to him by various people for

various reasons; some desired to see a brilliant demonstration of the truth; others whispered their hopes of a signal failure. The promoter of one very large experiment was a Melun veterinary surgeon, M. Rossignol.

In the *Veterinary Press*, of which M. Rossignol was one of the editors, an article by him might have been read on the 31st January, 1881, less than a month before that great discovery on charbon vaccine, wherein he expressed himself as follows: "Will you have some microbe? There is some everywhere. Microbiolatry is the fashion, it reigns undisputed; it is a doctrine which must not even be discussed, especially when its Pontiff, the learned M. Pasteur, has pronounced the sacramental words, *I have spoken*. The microbe alone is and shall be the characteristic of a disease; that is understood and settled; henceforth the germ theory must have precedence of pure clinics; the Microbe alone is true, and Pasteur is its prophet."

At the end of March, M. Rossignol began a campaign, begging for subscriptions, pointing out how much the cultivators of the Brie—whose cattle suffered almost as much as that of the Beauce—were interested in the question. The discovery, *if it were genuine*, should not remain confined to the Ecole Normale laboratory, or monopolized by the privileged public of the Académie des Sciences, who had no use for it. M. Rossignol soon collected about 100 subscribers. Did he believe that Pasteur and his little phials would come to a hopeless fiasco in a farmyard before a public of old practitioners who had always been powerless in the presence of splenic fever? Microbes were a subject for ceaseless joking; people had hilarious visions of the veterinary profession confined some twenty years hence in a model laboratory assiduously cultivating numberless races, sub-races, varieties and sub-varieties of microbes.

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It is probable that, if light comes from above, a good many practitioners would not have been sorry to see a strong wind from below putting out Pasteur's light.

M. Rossignol succeeded in interesting every one in this undertaking. When the project was placed before the Melun Agricultural Society on the 2nd April, they hastened to approve of it and to accord their patronage.

The chairman, Baron de la Rochette, was requested to approach Pasteur and to invite him to organize public experiments on the preventive vaccination of charbon in the districts of Melun, Fontainebleau and Provins.

"The noise which those experiments will necessarily cause," wrote M. Rossignol, "will strike every mind and convince those who may still be doubting; the evidence of facts will have the result of ending all uncertainty."

Baron de la Rochette was a typical old French gentleman; his whole person was an ideal of old-time distinction and courtesy. Well up to date in all agricultural progress, and justly priding himself, with the ease of a great land-owner, that he made of agriculture an art and a science, he could speak in any surroundings with knowledge of his subject and a winning grace of manner. When he entered the laboratory, he was at once charmed by the simplicity of the scientist, who hastened to accept the proposal of an extensive experiment.

At the end of April, Pasteur wrote out the programme which was to be followed near Melun at the farm of Pouilly le Fort. M. Rossignol had a number of copies of that programme printed, and distributed them, not only throughout the Department of Seine et Marne, but in the whole agricultural world. This programme was so decidedly affirmative that some one said to Pasteur, with a little anxiety: "You remember what Marshal Gouvion St. Cyr said of Napoleon, that 'he liked hazardous games

with a character of grandeur and audacity.' It was neck or nothing with him; you are going on in the same way!"

"Yes," answered Pasteur, who meant to compel a victory.

And as his collaborators, to whom he had just read the precise and strict arrangements he had made, themselves felt a little nervous, he said to them, "What has succeeded in the laboratory on fourteen sheep will succeed just as well at Melun on fifty."

This programme left him no retreat. The Melun Agricultural Society put sixty sheep at Pasteur's disposal; twenty-five were to be vaccinated by two inoculations, at twelve or fifteen days' interval, with some attenuated charbon virus. Some days later those twenty-five and also twenty-five others would be inoculated with some very virulent charbon culture.

"The twenty-five unvaccinated sheep will all perish," wrote Pasteur, "the twenty-five vaccinated ones will survive." They would afterwards be compared with the ten sheep which had undergone no treatment at all. It would thus be seen that vaccination did not prevent sheep from returning to their normal state of health after a certain time.

Then came other prescriptions, for instance, the burying of the dead sheep in distinct graves, near each other and enclosed within a paling.

"In May, 1882," added Pasteur, "twenty new sheep, that is, sheep never before used for experimentation, will be shut within that paling."

And he predicted that the following year, 1882, out of those twenty-five sheep fed on the grass of that little enclosure or on forage deposited there, several would become infected by the charbon germs brought to the surface by earthworms, and that they would die of splenic

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fever. Finally, twenty-five other sheep might be folded in a neighbouring spot, where no charbon victims had ever been buried, and under these conditions none would contract the disease.

M. de la Rochette having expressed a desire that cows should be included in the programme, Pasteur answered that he was willing to try that new experiment, though his tests on vaccine for cows were not as advanced as those on sheep vaccine. Perhaps, he said, the results may not be as positive, though he thought they probably would be. He was offered ten cows; six were to be vaccinated and four not vaccinated. The experiments were to begin on the Thursday, 5th May, and would in all likelihood terminate about the first fortnight in June.

At the time when M. Rossignol declared that all was ready for the fixed time, an editor's notice in the *Veterinary Press* said that the laboratory experiments were about to be repeated *in campo*, and that Pasteur could thus "demonstrate that he had not been mistaken when he affirmed before the astonished Academy that he had discovered the vaccine of splenic fever, a preventative to one of the most terrible diseases with which animals and even men could be attacked." This notice ended thus, with an unexpected classical reminiscence: "These experiments are solemn ones, and they will become memorable if, as M. Pasteur asserts, with such confidence, they confirm all those he has already instituted. We ardently wish that M. Pasteur may succeed and remain the victor in a tournament which has now lasted long enough. If he succeeds, he will have endowed his country with a great benefit, and his adversaries should, as in the days of antiquity, wreath their brows with laurel leaves and prepare to follow, chained and prostrate, the chariot of the immortal Victor. But he must succeed: such

is the price of triumph. Let M. Pasteur not forget that the Tarpeian Rock is near the Capitol."

On May 5 a numerous crowd arriving from Melun station or from the little station of Cesson, was seen moving towards the yard of Pouilly le Fort farm; it looked like a mobilisation of *Conseillers Généraux*, agricultors, physicians, apothecaries, and especially veterinary surgeons. Most of these last were full of scepticism—as was remarked by M. Thierry, who represented the Veterinary Society of the Yonne, and one of his colleagues, M. Biot, of Pont-sur-Yonne. They were exchanging jokes and looks to the complete satisfaction of Pasteur's adversaries. They were looking forward to the last and most virulent inoculation.

Pasteur, assisted not only by Messrs. Chamberland and Roux, but also by a third pupil of the name of Thuillier, proceeded to the arrangement of the subjects. At the last moment, two goats were substituted for two of the sheep.

Vaccination candidates and unvaccinated test sheep were divided under a large shed. For the injection of the vaccinal liquid, Pravaz's little syringe was used; those who have experienced morphia injections know how easily the needle penetrates the subcutaneous tissues. Each of the twenty-five sheep received, on the inner surface of the right thigh, five drops of the bacteridian culture which Pasteur called the first vaccine. Five cows and one ox substituted for the sixth cow were vaccinated in their turn, behind the shoulder. The ox and the cows were marked on the right horn, and the sheep on the ear.

Pasteur was, after this, asked to give a lecture on splenic fever in the large hall of the Pouilly farm. Then, in clear, simple language, meeting every objection half-way, showing no astonishment at ignorance or prejudice, knowing

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perfectly well that many were really hoping for a failure, he methodically described the road already travelled and pointed to the goal he would reach. For nearly an hour he interested and instructed his mixed audience ; he made them feel the genuineness of his faith, and, besides his interest in the scientific problem, his desire to spare heavy losses to cultivators. After the lecture, some, better informed than others, were admiring the logical harmony of that career, mingling with pure science results of incalculable benefit to the public, an extraordinary alliance which gave a special moral physiognomy to this man of prodigious labours.

An appointment was made for the second inoculation. In the interval—on May 6, 7, 8 and 9—Messrs. Chamberland and Roux came to Pouilly le Fort to take the temperature of the vaccinated animals, and found nothing abnormal. On May 17 a second inoculation was made with a liquid which, though still attenuated, was more virulent than the first. If that liquid had been inoculated to begin with it would have caused a mortality of 50 per 100.

“ On Tuesday, May 31,” wrote Pasteur to his son-in-law, “ the third and last inoculation will take place—this time with fifty sheep and ten cows. I feel great confidence—for the two first, on the 5th and the 17th, have been effected under the best conditions without any mortality amongst the twenty-five vaccinated subjects. On June 5 at latest the final result will be known, and should be twenty-five survivors out of twenty-five vaccinated, and six cows. If the success is complete, this will be one of the finest examples of applied science in this century, consecrating one of the greatest and most fruitful discoveries.”

This great experiment did not hinder other studies being pursued in the laboratory. The very day of the second inoculation at Pouilly le Fort, Mme. Pasteur wrote to her

daughter, "One of the laboratory dogs seems to be sicken-ing for hydrophobia ; it seems that that would be very lucky, in view of the interesting experiment it would provide."

On May 25, another letter from Mme. Pasteur shows how deeply each member of the family shared Pasteur's pre-occupations and hopes and was carried away with the stream of his ideas: "Your father has just brought great news from the laboratory. The new dog which was trephined and inoculated with hydrophobia died last night after nineteen days' incubation only. The disease manifested itself on the fourteenth day, and this morning the same dog was used for the trephining of a fresh dog, which was done by Roux with unrivalled skill. All this means that we shall have as many mad dogs as will be required for experiments, and those experiments will become extremely interesting.

"Next month one of the *master's* delegates will go to the south of France to study the 'rouget' of swine, which ordinarily rages at this time.

"It is much hoped that the vaccine of that disease will be found."

The trephining of that dog had much disturbed Pasteur. He, who was described in certain anti-vivisectionist quarters as a laboratory executioner, had a great horror of inflicting suffering on any animal.

"He could assist without too much effort," writes M. Roux, "at a simple operation such as a subcutaneous inoculation, and even then, if the animal screamed at all, Pasteur was immediately filled with compassion, and tried to comfort and encourage the victim, in a way which would have seemed ludicrous if it had not been touching. The thought of having a dog's cranium perforated was very disagreeable to him ; he very much wished that the experi-

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ment should take place, and yet he feared to see it begun. I performed it one day when he was out. The next day, as I was telling him that the intercranial inoculation had presented no difficulty, he began pitying the dog. ‘Poor thing ! His brain is no doubt injured, he must be paralysed !’ I did not answer, but went to fetch the dog, whom I brought into the laboratory. Pasteur was not fond of dogs, but when he saw this one, full of life, curiously investigating every part of the laboratory, he showed the keenest pleasure, and spoke to the dog in the most affectionate manner. Pasteur was infinitely grateful to this dog for having borne trephining so well, thus lessening his scruples for future trephining.”

As the day was approaching for the last experiments at Pouilly le Fort, excitement was increasing in the veterinary world. Every chance meeting led to a discussion ; some prudent men said “Wait.” Those that believed were still few in number.

One or two days before the third and decisive inoculation, the veterinary surgeon of Pont-sur-Yonne, M. Biot, who was watching with a rare scepticism the Pouilly le Fort experiments, met Colin on the road to Maisons-Alfort. “Our conversation”—M. Biot dictated the relation of this episode to M. Thierry, his colleague, also very sceptical and expecting the Tarpeian Rock—“our conversation naturally turned on Pasteur’s experiments. Colin said : ‘You must beware, for there are two parts in the bacteridia-culture broth: one upper part which is inert, and one deep part very active, in which the bacteridia become accumulated, having dropped to the bottom because of their weight. The vaccinated sheep will be inoculated with the upper part of the liquid, whilst the others will be inoculated with the bottom liquid, which will kill them.’ ” Colin advised M. Biot to seize at the last moment the phial

containing the virulent liquid and to shake it violently, "so as to produce a perfect mixture rendering the whole uniformly virulent."

If Bouley had heard such a thing, he would have lost his temper, or he would have laughed heartily. A year before this, in a letter to M. Thierry, who not only defended but extolled Colin, Bouley had written:

"No doubt Colin is a man of some value, and he has cleverly taken advantage of his position of Chief of the Anatomy department at Alfort to accomplish some important labours. But it is notable that his negative genius has ever led him to try and demolish really great work. He denied Davaine, Marey, Claude Bernard, Chauveau; now he is going for Pasteur." Bouley, to whom Colin was indebted for his situation at Alfort, might have added, "And he calls me his persecutor!" But Biot refused to believe in Colin's hostility and only credited him with scruples on the question of experimental physiology. Colin did not doubt M. Pasteur's *bonâ-fides*, M. Biot said, but only his aptitude to conduct experiments *in anima vili*.

On May 31, every one was at the farm. M. Biot executed Colin's indications and shook the virulent tube with real veterinary energy. He did more: still acting on advice from Colin, who had told him that the effective virulence was in direct proportion to the quantity injected, he asked that a larger quantity of liquid than had been intended should be inoculated into the animals. A triple dose was given. Other veterinary surgeons desired that the virulent liquid should be inoculated alternatively into vaccinated and unvaccinated animals. Pasteur lent himself to these divers requests with impassive indifference and without seeking for their motives.

At half-past three everything was done, and a rendezvous

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fixed for June 2 at the same place. The proportion between believers and unbelievers was changing. Pasteur seemed so sure of his ground that many were saying "He can surely not be mistaken." One little group had that very morning drunk to a *fiasco*. But, whether from a sly desire to witness a failure, or from a generous wish to be present at the great scientific victory, every man impatiently counted the hours of the two following days.

On June 4, Messrs. Chamberland and Roux went back to Pouilly le Fort to judge of the condition of the patients. Amongst the lot of unvaccinated sheep, several were standing apart with drooping heads, refusing their food. A few of the vaccinated subjects showed an increase of temperature, one of them even had 40° C. (104° Fahrenheit); one sheep presented a slight œdema of which the point of inoculation was the centre; one lamb was lame, another manifestly feverish, but all, save one, had preserved their appetite. All the unvaccinated sheep were getting worse and worse. "In all of them," noted M. Rossignol, "breathlessness is at its maximum; the heaving of the sides is now and then interrupted by groans. If the most sick are forced to get up and walk, it is with great difficulty that they advance a few steps, their limbs being so weak and vacillating." Three had died by the time M. Rossignol left Pouilly le Fort. "Everything leads me to believe," he wrote, "that a great number of sheep will succumb during the night."

Pasteur's anxiety was great when Messrs. Chamberland and Roux returned, having noticed a rise in the temperature of certain vaccinated subjects. It was increased by the arrival of a telegram from M. Rossignol announcing that he considered one sheep as lost. By a sudden reaction, Pasteur, who had drawn up such a bold programme, leaving no margin for the unexpected, and who the day before seemed

of an imperturbable tranquillity among all those sheep, the life or death of whom was about to decide between an immortal discovery and an irremediable failure, now felt himself beset with doubts and anguish.

Bouley, who had that evening come to see his *master*, as he liked to call him, could not understand this reaction—the result of too much strain on the mind, said M. Roux, whom it did not astonish. Pasteur's emotional nature, strangely allied to his fighting temperament, was mastering him. "His faith staggered for a time," writes M. Roux, "as if the experimental method could betray him." The night was a sleepless one.

"This morning, at eight o'clock," wrote Mme. Pasteur to her daughter, "we were still very much excited and awaiting the telegram which might announce some disaster. Your father would not let his mind be distracted from his anxiety. At nine o'clock the laboratory was informed, and the telegram handed to me five minutes later. I had a moment's emotion, which made me pass through all the colours of the rainbow. Yesterday, a considerable rise of temperature had been noticed with terror in one of the sheep; this morning that same sheep was well again."

On the arrival of the telegram Pasteur's face lighted up; his joy was deep, and he desired to share it immediately with his absent children. Before starting for Melun, he wrote them this letter:

"June 2, 1881.

"It is only Thursday, and I am already writing to you; it is because a great result is now acquired. A wire from Melun has just announced it. On Tuesday last, 31st May, we inoculated all the sheep, vaccinated and non-vaccinated, with very virulent splenic fever. It is not forty-eight hours ago. Well, the telegram tells me that, when we arrive at two o'clock this afternoon, all the non-vaccinated subjects

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will be dead; eighteen were already dead this morning, and the others dying. As to the vaccinated ones, they are all well; the telegram ends by the words '*stunning success*'; it is from the veterinary surgeon, M. Rossignol.

"It is too early yet for a final judgment; the vaccinated sheep might yet fall ill. But when I write to you on Sunday, if all goes well, it may be taken for granted that they will henceforth preserve their good health, and that the success will indeed have been startling. On Tuesday, we had a foretaste of the final results. On Saturday and Sunday, two sheep had been abstracted from the lot of twenty-five vaccinated sheep, and two from the lot of twenty-five non-vaccinated ones, and inoculated with a very virulent virus. Now, when on Tuesday all the visitors arrived, amongst whom were M. Tisserand, M. Patinot, the Prefect of Seine et Marne, M. Foucher de Careil, Senator, etc., we found the two unvaccinated sheep dead, and the two others in good health. I then said to one of the veterinary surgeons who were present, 'Did I not read in a newspaper, signed by you, à propos of the virulent little organism of saliva, "There! one more microbe; when there are 100 we shall make a cross."' 'It is true,' he immediately answered, honestly. 'But I am a converted and repentant sinner.' 'Well, I answered, allow me to remind you of the words of the Gospel: Joy shall be in heaven over one sinner that repented, more than over ninety and nine just persons which need no repentance.' Another veterinary surgeon who was present said, 'I will bring you another, M. Colin.' 'You are mistaken,' I replied. 'M. Colin contradicts for the sake of contradicting, and does not believe because he will not believe. You would have to cure a case of neurosis, and you cannot do that!' Joy reigns in the laboratory and in the house. Rejoice, my dear children."

When Pasteur arrived, at two o'clock in the afternoon, at

the farmyard of Pouilly le Fort, accompanied by his young collaborators, a murmur of applause arose, which soon became loud acclamation, bursting from all lips. Delegates from the Agricultural Society of Melun, from medical societies, veterinary societies, from the Central Council of Hygiene of Seine et Marne, journalists, small farmers who had been divided in their minds by laudatory or injurious newspaper articles—all were there. The carcases of twenty-two unvaccinated sheep were lying side by side ; two others were breathing their last ; the last survivors of the sacrificed lot showed all the characteristic symptoms of splenic fever. All the vaccinated sheep were in perfect health.

Bouley's happy face reflected the feelings which were so characteristic of his attractive personality : enthusiasm for a great cause, devotion to a great man. M. Rossignol, in one of those loyal impulses which honour human nature, disowned with perfect sincerity his first hasty judgment ; Bouley congratulated him. He himself, many years before, had allowed himself to judge too hastily, he said, of certain experiments of Davaine's, of which the results then appeared impossible. After having witnessed these experiments, Bouley had thought it a duty to proclaim his error at the Académie de Médecine, and to render a public homage to Davaine. "That, I think," he said, "is the line of conduct which should always be observed ; we honour ourselves by acknowledging our mistakes and by rendering justice to neglected merit."

No success had ever been greater than Pasteur's. The veterinary surgeons, until then the most incredulous, now convinced, desired to become the apostles of his doctrine. M. Biot spoke of nothing less than of being himself vaccinated and afterwards inoculated with the most active virus. Colin's absence was much regretted. Pasteur was not yet satisfied. "We must wait until the 5th of

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June," he said, "for the experiment to be complete, and the proof decisive."

M. Rossignol and M. Biot proceeded on the spot to the necropsy of two of the dead sheep. An abundance of bacteridia was very clearly seen in the blood through the microscope.

Pasteur was accompanied back to the station by an enthusiastic crowd, saluting him—with a luxury of epithets contrasting with former ironies—as the immortal author of the magnificent discovery of splenic fever vaccination, and it was decided that the farm of Pouilly le Fort would henceforth bear the name of *Clos Pasteur*.

The one remaining unvaccinated sheep died that same night. Amongst the vaccinated lot one ewe alone caused some anxiety. She was pregnant, and died on the 4th of June, but from an accident due to her condition, and not from the consequences of the inoculation, as was proved by a post-mortem examination.

Amongst the cattle, those which had been vaccinated showed no sign whatever of any disturbance; the others presented enormous œdemata.

Pasteur wrote to his daughter: "Success is definitely confirmed; the vaccinated animals are keeping perfectly well, the test is complete. On Wednesday a report of the facts and results will be drawn up which I shall communicate to the Académie des Sciences on Monday, and on Tuesday to the Académie de Médecine."

And, that same day, he addressed a joyful telegram to Bouley, who, in his quality of General Inspector of Veterinary Schools, had been obliged to go to Lyons. Bouley answered by the following letter:

"Lyons, June 5, 1881. Dearest Master, your triumph has filled me with joy. Though the days are long past now when my faith in you was still somewhat hesitating, not

having sufficiently impregnated my mind with your spirit, as long as the event—which has just been realized in a manner so rigorously in conformity with your predictions—was still in the future, I could not keep myself from feeling a certain anxiety, of which you were yourself the cause, since I had seen you also a prey to it, like all inventors on the eve of the day which reveals their glory. At last your telegram, *for which I was pining*, has come to tell me that the world has found you faithful to all your promises, and that you have inscribed one more great date in the *annals of Science*, and particularly in those of Medicine, for which you have opened a new era.

"I feel the greatest joy at your triumph; in the first place, for you, who are to-day receiving the reward of your noble efforts in the pursuit of Truth; and—shall I tell you?—for myself too, for I have so intimately associated myself with your work that I should have felt your failure absolutely as if it had been personal to me. All my teaching at the Museum consists in relating your labours and predicting their fruitfulness."

Those experiments at Pouilly le Fort caused a tremendous sensation; the whole of France burst out in an explosion of enthusiasm. Pasteur now knew fame under its rarest and purest form; the loving veneration, the almost worship with which he inspired those who lived near him or worked with him, had become the feeling of a whole nation.

On June 13, at the Académie des Sciences, he was able to state as follows his results and their practical consequences. "We now possess virus vaccines of charbon, capable of preserving from the deadly disease, without ever being themselves deadly—living vaccines, to be cultivated at will, transportable anywhere without alteration, and prepared by a method which we may believe susceptible of being generalized, since it has been the means of discover-

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ing the vaccine of chicken-cholera. By the character of the conditions I am now enumerating, and from a purely scientific point of view, the discovery of the vaccine of anthrax constitutes a marked step in advance of that of Jenner's vaccine, since the latter has never been experimentally obtained."

On all sides, it was felt that something very great, very unexpected, justifying every sort of hope, had been brought forth. Ideas of research were coming up. On the very morrow of the results obtained at Pouilly le Fort, Pasteur was asked to go to the Cape to study a contagious disease raging among goats.

"Your father would like to take that long journey," wrote Mme. Pasteur to her daughter, "passing on his way through Senegal to gather some good germs of pernicious fever; but I am trying to moderate his ardour. I consider that the study of hydrophobia should suffice him for the present."

He was at that time "at boiling point," as he put it—going from his laboratory work to the Academies of Sciences and Medicine to read some notes; then to read reports at the Agricultural Society; to Versailles, to give a lecture to an Agronomic Congress, and to Alfort to lecture to the professors and students. His clear and well arranged words, the connection between ideas and the facts supporting them, the methodical recital of experiments, allied to an enthusiastic view of the future and its prospects—especially when addressing a youthful audience—deeply impressed his hearers. Those who saw and heard him for the first time were the more surprised that, in certain circles, a legend had formed round Pasteur's name. He had been described as of an irritable, intolerant temper, domineering and authoritative, almost despotic; and people now saw a man of perfect simplicity, so modest that he did

not seem to realize his own glory, pleased to answer—even to provoke—every objection, only raising his voice to defend Truth, to exalt Work, and to inspire love for France, which he wished to see again in the first rank of nations. He did not cease to repeat that the country must regain her place through scientific progress. Boys and youths—ever quick to penetrate the clever calculations of those who seek their own interest instead of accomplishing a duty—listened to him eagerly and, very soon conquered, enrolled themselves among his followers. In him they recognized the three rarely united qualities which go to form true benefactors of humanity: a mighty genius, great force of character, and genuine goodness.

The Republican Government, desirous of recognizing this great discovery of splenic fever vaccination, offered him the Grand Cordon of the Legion of Honour. Pasteur put forward one condition; he wanted, at the same time, the red ribbon for his two collaborators. "What I have most set my heart upon is to obtain the Cross for Chamberland and Roux," he wrote to his son in law on June 26; "only at that price will I accept the Grand Cross. They are taking such trouble! Yesterday they went to a place fifteen kilometres from Senlis, to vaccinate ten cows and 250 sheep. On Thursday we vaccinated 300 sheep at Vincennes. On Sunday they were near Coulommiers. On Friday we are going to Pithiviers. What I chiefly wish is that the discovery should be consecrated by an exceptional distinction to two devoted young men, full of merit and courage. I wrote yesterday to Paul Bert, asking him to intervene most warmly in their favour."

One of Pasteur's earliest friends, who, in 1862, had greeted with joy his election to the Académie des Sciences, and who had never ceased to show the greatest interest in the progress due to the experimental method, entered the

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Ecole Normale laboratory with a beaming face. Happy to bring good tidings, he took his share of them like the devoted, hardworking, kindly man that he was. "M. Grandea," wrote Mme. Pasteur to her children, "has just brought to the laboratory the news that Roux and Chamberland have the Cross and M. Pasteur the Grand Cross of the Legion of Honour. Hearty congratulations were exchanged in the midst of the rabbits and guinea-pigs."

Those days were darkened by a great sorrow. Henri Sainte Claire Deville died. Pasteur was then reminded of the words of his friend in 1868: "You will survive me, I am your senior; promise that you will pronounce my funeral oration." When formulating this desire, Sainte Claire Deville had no doubt been desirous of giving another direction to the presentiments of Pasteur, who believed himself death-stricken. But, whether it was from a secret desire, or from an affectionate impulse, he felt that none understood him better than Pasteur. Both loved Science after the same manner; they gave to patriotism its real place; they had hopes for the future of the human mind; they were moved by the same religious feelings before the mysteries of the Infinite.

Pasteur began by recalling his friend's wish: "And here am I, before thy cold remains, obliged to ask my memory what thou wert in order to repeat it to the multitude crowding around thy coffin. But how superfluous! Thy sympathetic countenance, thy witty merriment and frank smile, the sound of thy voice remain with us and live within us. The earth which bears us, the air we breathe, the elements, often interrogated and ever docile to answer thee, could speak to us of thee. Thy services to Science are known to the whole world, and every one who

has appreciated the progress of the human mind is now mourning for thee."

He then enumerated the scientist's qualities, the inventive precision of that eager mind, full of imagination, and at the same time the strictness of analysis and the fruitful teaching so delightedly recognized by those who had worked with him, Debray, Troost, Fouqué, Grandeaum, Hautefeuille, Gernez, Lechartier. Then, showing that, in Sainte Claire Deville, the man equalled the scientist :

"Shall I now say what thou wert in private life? Again, how superfluous! Thy friends do not want to be reminded of thy warm heart. Thy pupils want no proofs of thy affection for them and thy devotion in being of service to them! See their sorrow.

"Should I tell thy sons, thy five sons, thy joy and pride, of the preoccupations of thy paternal and prudent tenderness? And can I speak of thy smiling goodness to her, the companion of thy life, the mere thought of whom filled thy eyes with a sweet emotion?

"Oh! I implore thee, do not now look down upon thy weeping wife and afflicted sons: thou wouldest regret this life too much! Wait for them rather in those divine regions of knowledge and full light, where thou knowest all now, where thou canst understand the Infinite itself, that terrible and bewildering notion, closed for ever to man in this world, and yet the eternal source of all Grandeur, of all Justice and all Liberty."

Pasteur's voice was almost stifled by his tears, as had been that of J. B. Dumas speaking at Péclet's tomb. The emotions of savants are all the deeper that they are not enfeebled, as in so many writers or speakers, by the constant use of words which end by wearing out the feelings.

Little groups slowly walking away from a country

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churchyard seem to take with them some of the sadness they have been feeling, but the departure from a Paris cemetery gives a very different impression. Life immediately grasps again and carries away in its movement the mourners, who now look as if they had been witnessing an incident in which they were not concerned. Pasteur felt such bitter contrasts with all his tender soul, he had a cult for dear memories; Sainte Claire Deville's portrait ever remained in his study.

The adversaries of the new discovery now had recourse to a new mode of attack. The virus which had been used at Pouilly le Fort to show how efficacious were the preventive vaccinations, was, they said, a culture virus—some even said a Machiavellian preparation of Pasteur's. Would vaccinated animals resist equally well the action of the charbon blood itself, the really malignant and infallibly deadly blood? Those sceptics were therefore impatiently awaiting the result of some experiments which were being carried out near Chartres in the farm of Lambert. Sixteen Beauceron sheep were joined to a lot of nineteen sheep brought from Alfort and taken from the herd of 300 sheep vaccinated against charbon three weeks before, on the very day of the lecture at Alfort. On July 16, at 10 o'clock in the morning, the thirty-five sheep, vaccinated and non-vaccinated, were gathered together. The corpse of a sheep who had died of charbon four hours before, in a neighbouring farm, was brought into the field selected for the experiments. After making a post-mortem examination and noting the characteristic injuries of splenic fever, ten drops of the dead sheep's blood were injected into each of the thirty-five sheep, taking one vaccinated at Alfort and one non-vaccinated Beauceron alternately. Two days later, on July 18, ten of the latter were already

dead, most of the others were prostrated. The vaccinated sheep were perfectly well.

While the ten dead sheep were being examined, two more died, and three more on the 19th. Bouley, informed by the veterinary surgeon, Boutet, of those successive incidents, wrote on the 20th to Pasteur: "My dear Master, Boutet has just informed me of the Chartres event. All has been accomplished according to the master's words; your vaccinated sheep have triumphantly come through the trial, and all the others save one are dead. That result is of special importance in a country-side where incredulity was being maintained in spite of all the demonstrations made. It seems that the doctors especially were refractory. They said it was too good to be true, and they counted on the strength of the natural charbon to find your method in default. Now they are converted, Boutet writes, and the veterinary surgeon too—one amongst others, whose brain it seems, was absolutely *iron-clad*—also the agricultors. There is a general Hosannah in your honour."

After congratulating Pasteur on the Grand Cross, he added, "I was also very glad of the reward you have obtained for your two young collaborators, so full of your spirit, so devoted to your work and your person, and whose assistance is so self-sacrificing and disinterested. The Government has honoured itself by so happily crowning with that distinction the greatness of the discovery in which they took part."

Henceforth, and for a time, systematic opposition ceased. Thousands and thousands of doses were used of the new vaccine, which afterwards saved millions to agriculture.

A few days later, came a change in Pasteur's surroundings. He was invited by the Organizing Committee to attend the International Medical Congress in London, and desired by the Government of the Republic to represent France.

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On August 3, when he arrived in St. James' Hall, filled to overflowing, from the stalls to the topmost galleries, he was recognized by one of the stewards, who invited him to come to the platform reserved for the most illustrious members of the Congress. As he was going towards the platform, there was an outburst of applause, hurrahs and acclamations. Pasteur turned to his two companions, his son and his son-in-law, and said, with a little uneasiness: "It is no doubt the Prince of Wales arriving; I ought to have come sooner."

"But it is you that they are all cheering," said the President of the Congress, Sir James Paget, with his grave, kindly smile.

A few moments later, the Prince of Wales entered, accompanying his brother-in-law, the German Crown Prince.

In his speech, Sir James Paget said that medical science should aim at three objects: novelty, utility and charity. The only scientist named was Pasteur; the applause was such that Pasteur, who was sitting behind Sir James Paget, had to rise and bow to the huge assembly.

"I felt very proud," wrote Pasteur to Mme. Pasteur in a letter dated that same day, "I felt inwardly very proud, not for myself—you know how little I care for triumph!—but for my country, in seeing that I was specially distinguished among that immense concourse of foreigners, especially of Germans, who are here in much greater numbers than the French, whose total however reaches two hundred and fifty. Jean Baptiste and René were in the Hall; you can imagine their emotion.

"After the meeting, we lunched at Sir James Paget's house; he had the Prussian Crown Prince on his right and the Prince of Wales on his left. Then there was a gathering of about twenty-five or thirty guests in the drawing-room. Sir James presented me to the Prince of Wales, to

whom I bowed, saying that I was happy to salute a friend to France. ‘Yes,’ he answered, ‘a great friend.’ Sir James Paget had the good taste not to ask me to be presented to the Prince of Prussia; though there is of course room for nothing but courtesy under such circumstances, I could not have brought myself to appear to wish to be presented to him. But he himself came up to me and said, ‘M. Pasteur, allow me to introduce myself to you, and to tell you that I had great pleasure in applauding you just now,’ adding some more pleasant things.”

In the midst of the unexpected meetings brought about by that Congress, it was an interesting thing to see this son of a King and Emperor, the heir to the German crown, thus going towards that Frenchman whose conquests were made over disease and death. Of what glory might one day dream this Prince, who became Frederic III!

His tall and commanding stature, the highest position in the Prussian army conferred on him by his father, King William, in a solemn letter dated from Versailles, October 1870,—everything seemed to combine in making a warlike man of this powerful-looking prince. And yet was it not said in France that he had protested against certain barbarities, coldly executed by some Prussian generals during that campaign of 1870? Had he not considered the clauses of the Treaty of Frankfort as Draconian and dangerous? If he had been sole master, would he have torn Alsace away from France? What share would his coming reign bear in the history of civilization? . . . Fate had already marked this Prince, only fifty years old, for an approaching death. In his great sufferings, before the inexorable death which was suffocating him, he was heroically patient. His long agony began at San Remo, amongst the roses and sunshine; he was an Emperor for

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less than one hundred days, and, on his death-bed, words of peace, peace for his people, were on his lips.

As Pasteur, coming to this Congress, was not only curious to see what was the place held in medicine and surgery by the germ-theory, but also desirous to learn as much as possible, he never missed a discussion and attended every meeting. It was in a simple sectional meeting that Bastian attempted to refute Lister. After his speech, the President suddenly said, "I call on M. Pasteur," though Pasteur had not risen. There was great applause; Pasteur did not know English; he turned to Lister and asked him what Bastian had said.

"He said," whispered Lister, "that microscopic organizations in disease were formed by the tissues themselves."

"That is enough for me," said Pasteur. And he then invited Bastian to try the following experiment:

"Take an animal's limb, crush it, allow blood and other normal or abnormal liquids to spread around the bones, only taking care that the skin should neither be torn nor opened in any way, and I defy you to see any micro-organism formed within that limb as long as the illness will last."

Pasteur, desired to do so by Sir James Paget at one of the great General Meetings of the Congress, gave a lecture on the principles which had led him to the attenuation of virus, on the methods which had enabled him to obtain the vaccines of chicken-cholera and of charbon, and, finally, on the results obtained. "In a fortnight," he said, "we vaccinated, in the Departments surrounding Paris, nearly 20,000 sheep, and a great many oxen, cows and horses. . . .

"Allow me," he continued, "not to conclude without telling you of the great joy that I feel in thinking that it is as a member of the International Medical Congress sitting in London that I have made known to you the vaccination of

a disease more terrible perhaps for domestic animals than is small-pox for man. I have given to the word vaccination an extension which I hope Science will consecrate as an homage to the merit and immense services rendered by your Jenner, one of England's greatest men. It is a great happiness to me to glorify that immortal name on the very soil of the noble and hospitable city of London!"

"Pasteur was the greatest success of the Congress," wrote the correspondent of the *Journal des Débats*, Dr. Daremberg, glad as a Frenchman and as a physician to hear the unanimous hurrahs which greeted the delegate of France. "When M. Pasteur spoke, when his name was mentioned, a thunder of applause rose from all benches, from all nations. An indefatigable worker, a sagacious seeker, a precise and brilliant experimentalist, an implacable logician, and an enthusiastic apostle, he has produced an invincible effect on every mind."

The English people, who chiefly look in a great man for power of initiative and strength of character, shared this admiration. One group only, alone in darkness, away from the Congress, was hostile to the general movement and was looking for an opportunity for direct or indirect revenge; it was the group of antivaccinators and anti-vivisectionists. The influence of the latter was great enough in England to prevent experimentation on animals. At a general meeting of the Congress, Virchow, the German scientist, spoke on the use of experimenting in pathology.

Already at a preceding Congress held in Amsterdam, Virchow had said amid the applause of the Assembly: "Those who attack vivisection have not the faintest idea of Science, and even less of the importance and utility of vivisection for the progress of medicine." But to this just argument, the international leagues for the protection of

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animals—very powerful, like everything that is founded on a sentiment which may be exalted—had answered by combative phrases. The physiological laboratories were compared to chambers of torture. It seemed as if, through caprice or cruelty, quite uselessly at any rate, this and that man of science had the unique desire of inflicting on bound animals, secured on a board, sufferings of which death was the only limit. It is easy to excite pity towards animals; an audience is conquered as soon as dogs are mentioned. Which of us, whether a cherished child, a neglected old maid, a man in the prime of his youth or a misanthrope weary of everything, has not, holding the best place in his recollections, the memory of some example of fidelity, courage or devotion given by a dog? In order to raise the revolt, it was sufficient for anti-vivisectionists to evoke amongst the ghosts of dog martyrs, the oft-quoted dog who, whilst undergoing an experiment, licked the hand of the operator. As there had been some cruel abuses on the part of certain students, those abuses alone were quoted. Scientists did not pay much heed to this agitation, partly a feminine one: they relied on the good sense of the public to put an end to those doleful declamations. But the English Parliament voted a Bill prohibiting vivisection; and, after 1876, English experimentalists had to cross the Channel to inoculate a guinea-pig.

Virchow did not go into details; but, in a wide exposé of Experimental Physiological Medicine, he recalled how, at each new progress of Science—at one time against the dissection of dead bodies and now against experiments on living animals,—the same passionate criticisms had been renewed. The Interdiction Bill voted in England had filled a new Leipzig Society with ardour; it had asked the Reichstag in that same year, 1881, to pass a law punishing cruelty to animals under pretext of scientific research, by imprison-

ment, varying between five weeks and two years, and deprivation of civil rights. Other societies did not go quite so far, but asked that some of their members should have a right of entrance and inspection into the laboratories of the Faculties.

"He who takes more interest in animals than in Science and in the knowledge of truth is not qualified to inspect officially things pertaining to Science," said Virchow. With an ironical gravity on his quizzical wrinkled face, he added, "Where shall we be if a scientist who has just begun a bona fide experiment finds himself, in the midst of his researches, obliged to answer questions from a new-comer and afterwards to defend himself before some magistrate for the crime of not having chosen another method, other instruments, perhaps another experiment? . . .

"We must prove to the whole world the soundness of our cause," concluded Virchow, uneasy at those "leagues" which grew and multiplied, and scattered through innumerable lecture halls the most fallacious judgments on the work of scientists.

Pasteur might have brought him, to support his statements relative to certain deviations of ideas and sentiments, numberless letters which reached him regularly from England—letters full of threats, insults and maledictions, devoting him to eternal torments for having multiplied his crimes on the hens, guinea-pigs, dogs and sheep of the laboratory. Love of animals carries some women to such lengths!

It would have been interesting, if, after Virchow's speech, some French physician had in his turn related a series of facts, showing how prejudices equally tenacious had had to be struggled against in France, and how *savants* had succeeded in enforcing the certainty that there can be no pathological science if Physiology is not progressing, and

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that it can only progress by means of the experimental method. Claude Bernard had expressed this idea under so many forms that it would almost have been enough to give a few extracts from his works.

In 1841, when he was Magendie's curator, he was one day attending a lesson on experimental physiology, when he saw an old man come in, whose costume—a long coat with a straight collar and a hat with a very wide brim—indicated a Quaker.

"Thou hast no right," he said, addressing Magendie, "to kill animals or to make them suffer. Thou givest a wicked example and thou accustomest thy fellow creatures to cruelty."

Magendie replied that it was a pity to look at it from that point of view, and that a physiologist, when moved by the thought of making a discovery useful to Medicine, and consequently useful to his fellow-creatures, did not deserve that reproach.

"Your countryman Harvey," said he, hoping to convince him, "would not have discovered the circulation of the blood if he had not made some experiments in vivisection. That discovery was surely worth the sacrifice of a few deer in Charles the First's Park?"

But the Quaker stuck to his idea ; his mission, he said, was to drive three things from this world : war, hunting and shooting, and experiments on live animals. Magendie had to show him out.

Three years later, Claude Bernard, in his turn, was taxed with barbarity by a Police Magistrate. In order to study the digestive properties of gastric juice, it had occurred to him to collect it by means of a cannula, a sort of silver tap which he adapted to the stomach of live dogs. A Berlin surgeon, M. Dieffenbach, who was staying in Paris, expressed a wish to see this application of a cannula

to the stomach. M. Pelouze, the chemist, had a laboratory in the Rue Dauphine; he offered it to Claude Bernard. A stray dog was used as a subject for the experiment and shut up in the yard of the house, where Claude Bernard wished to keep a watch on him. But, as the treatment in no wise hindered the dog from running about, the door of the yard was hardly opened when he escaped, cannula and all.

"A few days later," writes Claude Bernard in the course of an otherwise grave report concerning the progress of general physiology in France (1867), "I was still in bed, early one morning, when I received a visit from a man who came to tell me that the Police Commissary of the Medicine School District wished to speak to me, and that I must go round to see him. I went in the course of the day to the Police Commissariat of the Rue du Jardinet; I found a very respectable-looking little old man, who received me very coldly at first and without saying anything. He took me into another room and showed me, to my great astonishment, the dog on whom I had operated in M. Pelouze's laboratory, asking me if I confessed to having fixed that instrument in his stomach. I answered affirmatively, adding that I was delighted to see my cannula, which I thought I had lost. This confession, far from satisfying the Commissary, apparently provoked his wrath, for he gave me an admonition of most exaggerated severity, accompanied with threats for having had the audacity to steal his dog to experiment on it.

"I explained that I had not stolen his dog, but that I had bought it of some individuals who sold dogs to physiologists, and who claimed to be employed by the police in picking up stray dogs. I added that I was sorry to have been the involuntary cause of the grief occasioned in his household by the misadventure to the dog, but that the

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animal would not die of it ; that the only thing to do was to let me take away my silver cannula and let him keep his dog. Those last words altered the Commissary's language and completely calmed his wife and daughter. I removed my instrument and left, promising to return, which I did the next and following days. The dog was perfectly cured in a day or two, and I became a friend of the family, completely securing the Commissary's future protection. It was on that account that I soon after set up my laboratory in his District, and for many years continued my private classes of experimental physiology, enjoying the protection and warnings of the Commissary and thus avoiding much unpleasantness, until the time when I was at last made an assistant to Magendie at the Collège de France."

The London Society for the Protection of Animals had the singular idea of sending to Napoleon III complaints, almost remonstrances, on the vivisection practised within the French Empire. The Emperor simply sent on those English lamentations to the Academy of Medicine. The matter was prolonged by academical speeches. In a letter addressed to M. Grandjeau, undated, but evidently written in August, 1863, Claude Bernard showed some irritation, a rare thing with him. Declaring that he would not go to the Academy and listen to the "nonsense" of "those who protect animals in hatred of mankind" he gave his concluding epitome: "You ask me what are the principal discoveries due to vivisection, so that you can mention them as arguments for that kind of study. All the knowledge possessed by experimental physiology can be quoted in that connection ; there is not a single fact which is not the direct and necessary consequence of vivisection. From Galen, who, by cutting the laryngeal nerves, learnt their use for respiration and the voice, to Harvey, who discovered

circulation; Pecquet and Aselli, the lymphatic vessels; Haller, muscular irritability; Bell and Magendie, the nervous functions, and all that has been learnt since the extension of that method of vivisection, which is the only experimental method; in biology, all that is known on digestion, circulation, the liver, the sympathetic system, the bones, Development—all, absolutely all, is the result of vivisection, alone or combined with other means of study."

In 1875, he again returned to this idea in his experimental medicine classes at the Collège de France: "It is to experimentation that we owe all our precise notions on the functions of the viscera and *a fortiori* on the properties of such organs as muscles, nerves, etc."

One more interesting quotation might have been offered to the members of the Congress. A Swede had questioned Darwin on vivisection, for the anti-vivisectionist propaganda was spreading on every side. Darwin, who, like Pasteur, did not admit that useless suffering should be inflicted on animals, (Pasteur carried this so far that he would never, he said, have had the courage to shoot a bird for sport)—Darwin, in a letter dated April 14th, 1881, approved any measures that could be taken to prevent cruelty, but he added: "On the other hand, I know that physiology can make no progress if experiments on living animals are suppressed, and I have an intimate conviction that to retard the progress of physiology is to commit a crime against humanity. . . . Unless one is absolutely ignorant of all that Science has done for humanity, one must be convinced that physiology is destined to render incalculable benefits in the future to man and even to animals. See the results obtained by M. Pasteur's work on the germs of contagious diseases: will not animals be the first to profit thereby? How many lives have been saved, how much suffering spared by the discovery of parasitic worms follow-

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ing on experiments made by Virchow and others on living animals!"

The London Congress marked a step on the road of progress. Besides the questions which were discussed and which were capable of precise solution, the scientific spirit showed itself susceptible of permeating other general subjects. Instead of remaining the impassive Sovereign we are wont to fancy her, Science—and this was proved by Pasteur's discoveries and their consequences, as Paget, Tyndall, Lister, and Priestley loudly proclaimed—Science showed herself capable of associating with pure research and perpetual care for Truth, a deep feeling of compassion for all suffering and an ever-growing thirst for self-sacrifice.

Pasteur's speech at the London Medical Congress was printed at the request of an English M.P. and distributed to all the members of the House of Commons. Dr. H. Gueneau de Mussy, who had spent part of his life in England, having followed the Orleans family into exile, wrote to Pasteur on August 15, "I have been very happy in witnessing your triumph; you are raising us up again in the eyes of foreign nations."

Applause was to Pasteur but a stimulus to further efforts. He was proud of his discoveries, but not vain of the effect they produced; he said in a private letter: "The *Temps* again refers, in a London letter, to my speech at the Congress. What an unexpected success!"

Having heard that yellow fever had just been brought into the Gironde, at the Pauillac *lazaretto* by the vessel *Condé* from Senegal, Pasteur immediately started for Bordeaux. He hoped to find the microbe in the blood of the sick or the dead, and to succeed in cultivating it. M. Roux hastened to join his master.

If people spoke to Pasteur of the danger of infection,

"What does it matter?" he said. "Life in the midst of danger is *the* life, the real life, the life of sacrifice, of example, of fruitfulness."

He was vexed to find his arrival notified in the newspapers; it worried him not to be able to work and to travel *incognito*.

On September 17, he wrote to Mme. Pasteur: ". . . We rowed out to a great transport ship which is lying in the Pauillac roads, having just arrived. From our boat, we were able to speak to the men of the crew. Their health is good, but they lost seven persons at St. Louis, two passengers and five men of the crew. Save the captain and one engineer, they are all Senegalese negroes on that ship. We have been near another large steamboat, and yet another; their health is equally good. . . .

"The most afflicted ship is the *Condé*, which is in quarantine in the Pauillac roads, and near which we have not been able to go. She has lost eighteen persons, either at sea or at the *lazaretto*. . . ."

No experiment could be attempted—the patients were convalescent. "But," he wrote the next day, "the *Richelieu* will arrive between the 25th and 28th, I think with some passengers. . . . It is more than likely that there will have been deaths during the passage, and patients for the *lazaretto*. I am therefore awaiting the arrival of that ship with the hope—God forgive a scientist's passion!!—that I may attempt some researches at the Pauillac *lazaretto*, where I will arrange things in consequence. You may be sure I shall take every precaution. In the meanwhile, what shall I do in Bordeaux?

"I have made the acquaintance of the young librarian of the town library, which is a few doors from the Hôtel Richelieu, in the Avenues of Tourny. The library is opened to me at all hours: I am there even now, alone and very

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comfortably seated, surrounded with more Littré than I can possibly get through."

For some months, several members of the Académie Française—according to the traditions of the Society which has ever thought it an honour to number among its members scientists such as Cuvier, Flourens, Biot, Claude Bernard, J. B. Dumas—had been urging Pasteur to become a candidate to the place left vacant by Littré. Pasteur was anxious to know not only the works, but the life of him whose place he might be called upon to fill. It was with some emotion that he first came upon the following lines printed on the title page of the translation of the works of Hippocrates; they are a dedication by Littré to the memory of his father, a sergeant-major in the Marines under the Revolution.

" . . . Prepared by his lessons and by his example, I have been sustained through this long work by his ever present memory. I wish to inscribe his name on the first page of this book, in the writing of which he has had so much share from his grave, so that the work of the father should not be forgotten in the work of the son, and that a pious and just gratitude should connect the work of the living with the heritage of the dead. . . ."

Pasteur in 1876 had obeyed a similar filial feeling when he wrote on the first page of his *Studies on Beer*—

" To the memory of my father, a soldier under the first Empire, and a knight of the Legion of Honour. The more I have advanced in age, the better I have understood thy love and the superiority of thy reason. The efforts I have given to these Studies and those which have preceded them are the fruit of thy example and advice. Wishing to honour these pious recollections, I dedicate this work to thy memory."

The two dedications are very similar. Those two

soldiers' sons had kept the virile imprint of the paternal virtues. A great tenderness was also in them both ; Littré, when he lost his mother, had felt a terrible grief, comparable to Pasteur's under the same circumstances.

In spite of Pasteur's interest in studying Littré in the Bordeaux library, he did not cease thinking of yellow fever. He often saw M. Berchon, the sanitary director, and inquired of him whether there were any news of the *Richelieu*. A young physician, Dr. Talmy, had expressed a desire to join Pasteur at Bordeaux and to obtain permission, when the time came, to be shut up with the patients in the lazaretto. Pasteur wrote on December 25 to Mme. Pasteur : "There is nothing new save the Minister's authorization to Dr. Talmy to enter the lazaretto ; I have just telegraphed to him that he might start. The owners of the *Richelieu* still suppose that she will reach Pauillac on Tuesday. M. Berchon, who is the first to be informed of what takes place in the roads, will send me a telegram as soon as the *Richelieu* is signalled, and we shall then go—M. Talmy, Roux and I—to ascertain the state of the ship, of course without going on board, which we should not be allowed to do if it has a suspicious bill of health."

And, as Mme. Pasteur had asked what happened when a ship arrived, he continued in the same letter : "From his boat to windward, M. Berchon receives the ship's papers, giving the sanitary state of the ship day by day. Before passing from the hands of the captain of the vessel to those of the sanitary director, the papers are sprinkled over with chloride of lime.

"If there are cases of illness, all the passengers are taken to the lazaretto ; only a few men are left on board the ship, which is henceforth in quarantine, no one being allowed to leave or enter it.

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"God permit that, in the body of one of those unfortunate victims of medical ignorance, I may discover some specific microscopic being. And after that? Afterwards, it would be really beautiful to make that agent of disease and death become its own vaccine. Yellow fever is one of the three great scourges of the East—bubonic plague, cholera, and yellow fever. Do you know that it is already a fine thing to be able to put the problem in those words!"

The *Richelieu* arrived, but she was free from fever. The last passenger had died during the crossing and his body had been thrown into the sea.

Pasteur left Bordeaux and returned to his laboratory.

CHAPTER IV

1882-1884

PASTEUR was in the midst of some new experiments when he heard that the date of the election to the Académie Française was fixed for December 8. Certain candidates spent half their time in *fiacres*, paying the traditional calls, counting the voters, calculating their chances, and taking every polite phrase for a promise. Pasteur, with perfect simplicity, contented himself with saying to the Academicians whom he went to see, "I had never in my life contemplated the great honour of entering the Académie Française. People have been kind enough to say to me, 'Stand and you will be elected.' It is impossible to resist an invitation so glorious for Science and so flattering to myself."

One member of the Académie, Alexandre Dumas, refused to let Pasteur call on him. "I will not allow him to come and see me," he said; I will myself go and thank him for consenting to become one of us." He agreed with M. Grandea, who wrote to Pasteur that "when Claude Bernard and Pasteur consent to enter the ranks of a Society, all the honour is for the latter."

When Pasteur was elected, his youthfulness of sentiment was made apparent ; it seemed to him an immense honour to be one of the Forty. He therefore prepared his reception speech with the greatest care, without however allowing his scientific work to suffer. The life of his predecessor

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interested him more and more; to work in the midst of family intimacy had evidently been Littré's ideal of happiness.

Few people, beyond Littré's colleagues, know that his wife and daughter collaborated in his great work; they looked out the quotations necessary to that Dictionary, of which, if laid end to end, the columns would reach a length of thirty-seven kilomètres. The Dictionary, commenced in 1857, when Littré was almost sixty years old, was only interrupted twice: in 1861, when Auguste Comte's widow asked Littré for a biography of the founder of positive philosophy; and in 1870, when the life of France was compromised and arrested during long months.

Littré, poor and disinterested as he was, had been able to realize his only dream, which was to possess a house in the country. Pasteur, bringing to bear in this, as in all things, his habits of scrupulous accuracy, left his laboratory for one day, and visited that villa, situated near Maisons-Laffitte.

The gardener who opened the door to him might have been the owner of that humble dwelling; the house was in a bad state of repair, but the small garden gave a look of comfort to the little property. It had been the only luxury of the philosopher, who enjoyed cultivating vegetables while quoting Virgil, Horace or La Fontaine, and listened to the nightingale when early dawn found him still sitting at his work.

After visiting this house and garden, reflecting as they did the life of a sage, Pasteur said sadly, "Is it possible that such a man should have been so misjudged!"

A crucifix, hanging in the room where Littré's family were wont to work, testified to his respect for the beliefs of his wife and daughter. "I know too well," he said one day, "what are the sufferings and difficulties of human life,

to wish to take from any one convictions which may comfort them."

Pasteur also studied the Positivist doctrine of which Auguste Comte had been the pontiff and Littré the prophet. This scientific conception of the world affirms nothing, denies nothing, beyond what is visible and easily demonstrated. It suggests altruism, a "subordination of personality to sociability," it inspires patriotism and the love of humanity. Pasteur, in his scrupulously positive and accurate work, his constant thought for others, his self-sacrificing devotion to humanity, might have been supposed to be an adept of this doctrine. But he found it lacking in one great point. "Positivism," he said, "does not take into account the most important of positive notions, that of the Infinite." He wondered that Positivism should confine the mind within limits; with an impulse of deep feeling, Pasteur, the scientist, the slow and precise observer, wrote the following passage in his speech: "What is beyond? the human mind, actuated by an invincible force, will never cease to ask itself: What is beyond? . . . It is of no use to answer: Beyond is limitless space, limitless time or limitless grandeur; no one understands those words. He who proclaims the existence of the Infinite—and none can avoid it—accumulates in that affirmation more of the supernatural than is to be found in all the miracles of all the religions; for the notion of the Infinite presents that double character that it forces itself upon us and yet is incomprehensible. When this notion seizes upon our understanding, we can but kneel. . . . I see everywhere the inevitable expression of the Infinite in the world; through it, the supernatural is at the bottom of every heart. The idea of God is a form of the idea of the Infinite. As long as the mystery of the Infinite weighs on human thought, temples will be erected for the worship of the Infinite,

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whether God is called Brahma, Allah, Jehovah, or Jesus ; and on the pavement of those temples, men will be seen kneeling, prostrated, annihilated in the thought of the Infinite."

At that time, when triumphant Positivism was inspiring many leaders of men, the very man who might have given himself up to what he called "the enchantment of Science" proclaimed the Mystery of the universe ; with his intellectual humility, Pasteur bowed before a Power greater than human power. He continued with the following words, worthy of being preserved for ever, for they are of those which pass over humanity like a Divine breath : "Blessed is he who carries within himself a God, an ideal, and who obeys it : ideal of art, ideal of science, ideal of the gospel virtues, therein lie the springs of great thoughts and great actions ; they all reflect light from the Infinite."

Pasteur concluded by a supreme homage to Littré. "Often have I fancied him seated by his wife, as in a picture of early Christian times : he, looking down upon earth, full of compassion for human suffering ; she, a fervent Catholic, her eyes raised to heaven : he, inspired by all earthly virtues ; she, by every Divine grandeur ; uniting in one impulse and in one heart the twofold holiness which forms the aureole of the Man-God, the one proceeding from devotion to humanity, the other emanating from ardent love for the Divinity : she a saint in the canonic sense of the word, he a lay-saint. This last word is not mine ; I have gathered it on the lips of all those that knew him."

The two colleagues whom Pasteur had chosen for his Academic sponsors were J. B. Dumas and Nisard. Dumas, who appreciated more than any one the scientific progress due to Pasteur, and who applauded his brilliant success, was touched by the simplicity and modesty which his former pupil showed, now as in the distant past, when the

then obscure young man sat taking notes on the Sorbonne benches.

Their mutual relationship had remained unchanged when Pasteur, accompanied by one of his family, rang at Dumas' door in March, 1882, with the manuscript of his noble speech in his pocket ; he seemed more like a student, respectfully calling on his master, than like a *savant* affectionately visiting a colleague.

Dumas received Pasteur in a little private study adjoining the fine drawing-room where he was accustomed to dispense an elegant hospitality. Pasteur drew a stool up to a table and began to read, but in a shy and hurried manner, without even raising his eyes towards Dumas, who listened, enthroned in his armchair, with an occasional murmur of approbation. Whilst Pasteur's careworn face revealed some of his ardent struggles and persevering work, nothing perturbed Dumas' grave and gentle countenance. His smile, at most times prudently affable and benevolent in varying degree, now frankly illumined his face as he congratulated Pasteur. He called to mind his own reception speech at the Academy when he had succeeded Guizot, and the fact that he too had concluded by a confession of faith in his Creator.

Pasteur's other sponsor, Nisard, almost an octogenarian, was not so happy as Dumas ; death had deprived him of almost all his old friends. It was a great joy to him when Pasteur came to see him on the wintry Sunday afternoons ; he fancied himself back again at the Ecole Normale and the happy days when he reigned supreme in that establishment. Pasteur's deference, greater even perhaps than it had been in former times, aided the delightful delusion. Though Nisard was ever inclined to bring a shade of patronage into every intimacy, he was a conversationalist of the old and rare stamp. Pasteur enjoyed hearing

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Nisard's recollections and watching for a smile lighting up the almost blind face. Those Sunday talks reminded him of the old delightful conversations with Chappuis at the Besançon College when, in their youthful fervour, they read together André Chénier's and Lamartine's verses. Eighteen years later, Pasteur had not missed one of Sainte Beuve's lectures to the Ecole Normale students ; he liked that varied and penetrating criticism, opening sidelights on every point of the literary horizon. Nisard understood criticism rather as a solemn treaty, with clauses and conditions ; with his taste for hierarchy, he even gave different ranks to authors as if they had been students before his chair. But, when he spoke, the rigidity of his system was enveloped in the grace of his conversation. Pasteur had but a restricted corner of his mind to give to literature, but that corner was a privileged one ; he only read what was really worth reading, and every writer worthy of the name inspired him with more than esteem, with absolute respect. He had a most exalted idea of Literature and its influence on society ; he was saying one day to Nisard that Literature was a great educator : "The mind alone can if necessary suffice to Science ; both the mind and the heart intervene in Literature, and that explains the secret of its superiority in leading the general train of thought." This was preaching to an apostle : no homage to literature ever seemed too great in the eyes of Nisard.

He approved of the modest exordium in Pasteur's speech—

"At this moment when presenting myself before this illustrious assembly, I feel once more the emotion with which I first solicited your suffrages. The sense of my own inadequacy is borne in upon me afresh, and I should feel some confusion in finding myself in this place, were it not my duty to attribute to Science itself the honour—so

to speak, an impersonal one—which you have bestowed upon me."

The Permanent Secretary, Camille Doucet, well versed in the usages of the Institute, and preoccupied with the effect produced, thought that the public would not believe in such self-effacement, sincere as it was, and sent the following letter to Pasteur with the proof-sheet of his speech—

"Dear and honoured colleague, allow me to suggest to you a modification of your first sentence; your modesty is excessive."

Camille Doucet had struck out *the sense of my own inadequacy is borne in upon me afresh*, and further *so to speak, an impersonal one*. Pasteur consulted Nisard, and *the sense of my own inadequacy* was replaced by *the sense of my deficiencies*, while Pasteur adhered energetically to *so to speak, an impersonal one*; he saw in his election less a particular distinction than a homage rendered to Science in general.

A reception at the Académie Française is like a sensational first night at a theatre; a special public is interested days beforehand in every coming detail. Wives, daughters, sisters of Academicians, great ladies interested in coming candidates, widows of deceased Academicians, laureates of various Academy prizes—the whole literary world agitates to obtain tickets. Pasteur's reception promised to be full of interest, some even said piquancy, for it fell to Renan to welcome him.

In order to have a foretaste of the contrast between the two men it was sufficient to recall Renan's opening speech three years before, when he succeeded Claude Bernard. His thanks to his colleagues began thus—

"Your cenaculum is only reached at the age of Ecclesiastes, a delightful age of serene cheerfulness, when

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after a laborious prime, it begins to be seen that all is but vanity, but also that some vain things are worthy of being lingeringly enjoyed."

The two minds were as different as the two speeches ; Pasteur took everything seriously, giving to words their absolute sense ; Renan, an incomparable writer, with his supple, undulating style, slipped away and hid himself within the sinuosities of his own philosophy. He disliked plain statements, and was ever ready to deny when others affirmed, even if he afterwards blamed excessive negation in his own followers. He religiously consoled those whose faith he destroyed, and, whilst invoking the Eternal, claimed the right of finding fault even there. When applauded by a crowd, he would willingly have murmured *Noli me tangere*, and even added with his joyful mixture of disdain and good-fellowship, "Let infinitely witty men come unto me."

On that Thursday, April 27, 1882, the Institute was crowded. When the noise had subsided, Renan, seated at the desk as Director of the Academy between Camille Doucet, the Permanent Secretary, and Maxime du Camp, the Chancellor, declared the meeting opened. Pasteur, looking paler than usual, rose from his seat, dressed in the customary green-embroidered coat of an Academician, wearing across his breast the Grand Cordon of the Legion of Honour. In a clear, grave voice, he began by expressing his deep gratification, and, with the absolute knowledge and sincerity which always compelled the attention of his audience, of whatever kind, he proceeded to praise his predecessor. There was no artifice of composition, no struggle after effect, only a homage to the man, followed almost immediately by a confession of dissent on philosophic questions. He was listened to with attentive emotion, and when he showed the error of Positivism in

attempting to do away with the idea of the Infinite, and proclaimed the instinctive and necessary worship by Man of the great Mystery, he seemed to bring out all the weakness and the dignity of Man—passing through this world bowed under the law of Toil and with the prescience of the Ideal—into a startling and consolatory light.

One of the privileges of the Academician who receives a new member, is to remain seated in his armchair before a table, and to comfortably prepare to read his own speech, in answer, often in contradiction, to the first. Renan, visibly enjoying the presidential chair, smiled at the audience with complex feelings, understood by some who were his assiduous readers. Respect for so much work achieved by a scientist of the first rank in the world; a gratified feeling of the honour which reverted to France; some personal pleasure in welcoming such a man in the name of the Académie, and, at the same time in the opportunity for a light and ironical answer to Pasteur's beliefs—all these sensations were perceptible in Renan's powerful face, the benevolence of whose soft blue eyes was corrected by the redoubtable keenness of the smile.

He began in a caressing voice by acknowledging that the Academy was somewhat incompetent to judge of the work and glory of Pasteur. "But," he added, with graceful eloquence, "apart from the ground of the doctrine, which is not within our attributions, there is, Sir, a greatness on which our experience of the human mind gives us a right to pronounce an opinion; something which we recognize in the most varied applications, which belongs in the same degree to Galileo, Pascal, Michael-Angelo, or Molière; something which gives sublimity to the poet, depth to the philosopher, fascination to the orator, divination to the scientist.

"That common basis of all beautiful and true work, that

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divine fire, that indefinable breath which inspires Science, Literature, and Art—we have found it in you, Sir—it is Genius. No one has walked so surely through the circles of elemental nature; your scientific life is like unto a luminous tract in the great night of the Infinitesimally Small, in that last abyss where life is born."

After a brilliant and rapid enumeration of the Pastorian discoveries, congratulating Pasteur on having touched through his art the very confines of the springs of life, Renan went on to speak of truth as he would have spoken of a woman: "Truth, sir, is a great coquette; she will not be sought with too much passion, but often is most amenable to indifference. She escapes when apparently caught, but gives herself up if patiently waited for; revealing herself after farewells have been said, but inexorable when loved with too much fervour." And further: "Nature is plebeian, and insists upon work, preferring horny hands and careworn brows."

He then commenced a courteous controversy. Whilst Pasteur, with his vision of the Infinite, showed himself as religious as Newton, Renan, who enjoyed moral problems, spoke of Doubt with delectation. "The answer to the enigma which torments and charms us will never be given to us. . . . What matters it, since the imperceptible corner of reality which we see is full of delicious harmonies, and since life, as bestowed upon us, is an excellent gift, and for each of us a revelation of infinite goodness?"

Legend will probably hand to posterity a picture of Renan as he was in those latter days, ironically cheerful and unctuously indulgent. But, before attaining the quizzical tranquillity he now exhibited to the Academy, he had gone through a complete evolution. When about the age of forty-eight, he might bitterly have owned that there was not one basis of thought which in him had not crumbled

to dust. Beliefs, political ideas, his ideal of European civilization, all had fallen to the ground. After his separation from the Church, he had turned to historical science; Germany had appeared to him, as once to Madame de Staël and so many others, as a refuge for thinkers. It had seemed to him that a collaboration between France, England, and Germany would create "An invincible trinity, carrying the world along the road of progress through reason." But that German façade which he took for that of a temple hid behind it the most formidable barracks which Europe had ever known, and beside it were cannon foundries, death-manufactories, all the preparations of the German people for the invasion of France. His awakening was bitter; war as practised by the Prussians, with a method in their cruelty, filled him with grief.

Time passed and his art, like a lily of the desert growing amongst ruins, gave flowers and perfumes to surrounding moral devastation. A mixture of disdain and nobility now made him regard as almost imperceptible the number of men capable of understanding his philosophical elevation. Pasteur had bared his soul; Renan took pleasure in throwing light on the intellectual antithesis of certain minds, and on their points of contact.

"Allow me, Sir, to recall to you your fine discovery of right and left tartaric acids. . . . There are some minds which it is as impossible to bring together as it is impossible, according to your own comparison, to fit two gloves one into the other. And yet both gloves are equally necessary; they complete each other. One's two hands cannot be superposed, they may be joined. In the vast bosom of nature, the most diverse efforts, added to each other, combine with each other, and result in a most majestic unity."

Renan handled the French language, "this old and

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admirable language, poor but to those who do not know it," with a dexterity, a choice of delicate shades, of tasteful harmonies which have never been surpassed. Able as he was to define every human feeling, he went on from the above comparison, painting divergent intellectual capabilities, to the following imprecation against death: "Death, according to a thought admired by M. Littré, is but a function, the last and quietest of all. To me it seems odious, hateful, insane, when it lays its cold blind hand on virtue and on genius. A voice is in us, which only great and good souls can hear, and that voice cries unceasingly 'Truth and Good are the ends of thy life; sacrifice all to that goal'; and when, following the call of that siren within us, claiming to bear the promises of life, we reach the place where the reward should await us, the deceitful consoler fails us. Philosophy, which had promised us the secret of death, makes a lame apology, and the ideal which had brought us to the limits of the air we breathe, disappears from view at the supreme hour when we look for it. Nature's object has been attained; a powerful effort has been realized, and then, with characteristic carelessness, the enchantress abandons us and leaves us to the hooting birds of the night."

Renan, save in one little sentence in his answer to Pasteur—"The divine work accomplishes itself by the intimate tendency to what is Good and what is True in the universe"—did not go further into the statement of his doctrines. Perhaps he thought them too austere for his audience; he was wont to eschew critical and religious considerations when in a world which he looked upon as frivolous. Moreover he thought his own century amusing, and was willing to amuse it further. If he raised his eyes to Heaven, he said that we owe virtue to the Eternal, but that we have the right to add to it irony. Pasteur thought

it strange that irony should be applied to subjects which have beset so many great minds and which so many simple hearts solve in their own way.

The week which followed Pasteur's reception at the Académie Française brought him a manifestation of applause in the provinces. The town of Aubenas in the Ardèche was erecting a statue to Olivier de Serres, and desired to associate with the name of the founder of the silk industry in France in the sixteenth century, that of its preserver in the nineteenth.

This was the second time that a French town proclaimed its gratitude towards Pasteur. A few months before, the Melun Agricultural Society had held a special meeting in his honour, and had decided "to strike a medal with Pasteur's effigy on it, in commemoration of one of the greatest services ever rendered by Science to Agriculture."

But amidst this paean of praise, Pasteur, instead of dwelling complacently on the recollection of his experiments at Pouilly le Fort, was absorbed in one idea, characteristic of the man ; he wanted to at once begin some experiments on the peripneumonia of horned cattle. The veterinary surgeon, Rossignol, had just been speaking on this subject to the meeting. Pasteur, who had recently been asked by the Committee of Epizootic Diseases to inquire into the mortality often caused by the inoculation of the peripneumonia virus, reminded his hearers in a few words of the variable qualities of virus and how the slightest impurity in a virus may exercise an influence on the effects of that virus.

He and his collaborators had vainly tried to cultivate the virus of peripneumonia in chicken-broth, veal-broth, yeast-water, etc. They had to gather the virus from the lung of a cow which had died of peripneumonia, by means of tubes

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previously sterilized ; it was injected, with every precaution against alteration, under the skin of the tail of the animal, this part being chosen on account of the thickness of the skin and of the cellular tissue. By operating on other parts, serious accidents were apt to occur, the virus being extremely violent, so much so in fact that the local irritation sometimes went so far as to cause the loss of part of the tail. At the end of the same year (1882), Pasteur published in the *Recueil de la Médecine Vétérinaire* a paper indicating the following means of preserving the virus in a state of purity—

“ Pure virus remains virulent for weeks and months. One lung is sufficient to provide large quantities of it, and its purity can easily be tested in a stove and even in ordinary temperature. From one lung only, enough can be procured to be used for many animals. Moreover, without having recourse to additional lungs, the provision of virus could be maintained in the following manner : it would suffice, before exhausting the first stock of virus, to inoculate a young calf behind the shoulder. Death speedily supervenes, and all the tissues are infiltrated with a serosity, which in its turn becomes virulent. This also can be collected and preserved in a state of purity.” It remained to be seen whether virus thus preserved would become so attenuated as to lose all degree of virulence.

Aubenas, then, wished to follow the example of Melun. In deference to the unanimous wish of the inhabitants of the little town, Pasteur went there on the 4th of May. His arrival was a veritable triumph ; there were decorations at the station, floral arches in the streets, brass and other bands, speeches from the Mayor, presentation of the Municipal Council, of the Chamber of Commerce, etc., etc. Excitement reigned everywhere, and the music of the bands was almost drowned by the acclamations of the

people. At the meeting of the Agricultural Society, Pasteur was offered a medal with his own effigy, and a work of art representing genii around a cup, their hands full of cocoons. A little microscope--that microscope which had been called an impracticable instrument, fit for scientists only--figured as an attribute.

"For us all," said the President of the Aubenas Spinning Syndicate, "you have been the kindly magician whose intervention conjured away the scourge which threatened us; in you we hail our benefactor."

Pasteur, effacing his own personality as he had done at the Académie, laid all this enthusiasm and gratitude as an offering to Science.

"I am not its object, but rather a pretext for it," he said, and continued: "Science has been the ruling passion of my life. I have lived but for Science, and in the hours of difficulty which are inherent to protracted efforts, the thought of France upheld my courage. I associated her greatness with the greatness of Science.

"By erecting a statue to Olivier de Serres, the illustrious son of the Vivarais, you give to France a noble example; you show to all that you venerate great men and the great things they have accomplished. Therein lies fruitful seed; you have gathered it, may your sons see it grow and fructify. I look back upon the time, already distant, when, desirous of responding to the suggestions of a kind and illustrious friend, I left Paris to study in a neighbouring Department the scourge which was decimating your *magnaneries*. For five years I struggled to obtain some knowledge of the evil and the means of preventing it; and, after having found it, I still had to struggle to implant in other minds the convictions I had acquired.

"All that is past and gone now, and I can speak of it with moderation. I am not often credited with that

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characteristic, and yet I am the most hesitating of men, the most fearful of responsibility, so long as I am not in possession of a proof. But when solid scientific proofs confirm my convictions, no consideration can prevent me from defending what I hold to be true.

"A man whose kindness to me was truly paternal (Biot), had for his motto: *Per vias rectas*. I congratulate myself that I borrowed it from him. If I had been more timid or more doubtful in view of the principles I had established, many points of science and of application might have remained obscure and subject to endless discussion. The hypothesis of spontaneous generation would still throw its veil over many questions. Your nurseries of silkworms would be under the sway of charlatanism, with no guide to the production of good seed. The vaccination of charbon, destined to preserve agriculture from immense losses, would be misunderstood and rejected as a dangerous practice.

"Where are now all the contradictions? They pass away, and Truth remains. After an interval of fifteen years, you now render it a noble testimony. I therefore feel a deep joy in seeing my efforts understood and celebrated in an impulse of sympathy which will remain in my memory and in that of my family as a glorious recollection."

Pasteur was not allowed to return at once to his laboratory. The agricultors and veterinary surgeons of Nîmes, who had taken an interest in all the tests on the vaccination of charbon, had, in their turn, drawn up a programme of experiments.

Pasteur arrived at a meeting of the Agricultural Society of the Gard in time to hear the report of the veterinary surgeons and to receive the congratulations of the Society. The President expressed to him the gratitude of all the cattle-owners and breeders hitherto powerless to arrest the

progress of the disease which he had now vanquished. Whilst a commemoration medal was being offered to him and a banquet being prepared—for Southern enthusiasm always implies a series of toasts—Pasteur thanked these enterprising men who were contemplating new experiments in order to dispel the doubts of a few veterinary surgeons, and especially the characteristic distrust, felt by some of the shepherds, of everything that did not come from the South. Sheep, oxen, and horses, some of them vaccinated, others intact, were put at Pasteur's disposal; he, with his usual energy, fixed the experiments for the next morning at eight o'clock. After inoculating all the animals with the charbon virus, Pasteur announced that those which had been vaccinated would remain unharmed, but that the twelve unvaccinated sheep would be dead or dying within forty-eight hours. An appointment was made for next day but one, on May 11, at the town knacker's, near the Bridge of Justice, where post-mortem examinations were made. Pasteur then went on to Montpellier, where he was expected by the Hérault Central Society of Agriculture, who had also made some experiments and had asked him to give a lecture at the Agricultural School. He entered the large hall, feeling very tired, almost ill, but his face lighted up at the sight of that assembly of professors and students who had hurried from all the neighbouring Faculties, and those agricultors crowding from every part of the Department, all of them either full of scientific curiosity or moved by their agricultural interests. His voice, at first weak and showing marks of weariness, soon became strengthened, and, forgetting his fatigue, he threw himself into the subject of virulent and contagious diseases. He gave himself up, heart and soul, to this audience for two whole hours, inspiring every one with his own enthusiasm. He stopped now and then to invite

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questions, and his answers to the objectors swept away the last shred of resistance.

"We must not," said the Vice-President of the Agricultural Society, M. Vialla, "encroach further on the time of M. Pasteur, which belongs to France itself. Perhaps, however, he will allow me to prefer a last request: he has delivered us from the terrible scourge of splenic fever; will he now turn to a no less redoubtable infection, viz. rot, which is, so to speak, endemic in our regions? He will surely find the remedy for it."

"I have hardly finished my experiments on splenic fever," answered Pasteur gently, "and you want me to find a remedy for rot! Why not for phylloxera as well?" And, while regretting that the days were not longer, he added, with the energy of which he had just given a new proof: "As to efforts, I am yours *usque ad mortem*."

He afterwards was the honoured guest at the banquet prepared for him. It was now not only Sericulture, but also Agriculture, which proclaimed its infinite gratitude to him; he was given an enthusiastic ovation, in which, as usual, he saw no fame for himself, but for work and science only.

On May 11, at nine o'clock in the morning, he was again at Nîmes, to meet the physicians, veterinary surgeons, cattle-breeders, and shepherds at the Bridge of Justice. Of the twelve sheep, six were already dead, the others dying; it was easy to see that their symptoms were the same as are characteristic of the ordinary splenic fever. "M. Pasteur gave all necessary explanations with his usual modesty and clearness," said the local papers.

"And now let us go back to work!" exclaimed Pasteur, as he stepped into the Paris express; he was impatient to return to his laboratory.

In order to give him a mark of public gratitude greater

still than that which came from this or that district, the Académie des Sciences resolved to organize a general movement of Scientific Societies. It was decided to present him with a medal, engraved by Alphée Dubois, and bearing on one side Pasteur's profile and on the other the inscription : "To Louis Pasteur, his colleagues, his friends, and his admirers."

On June 25, a Sunday, a delegation, headed by Dumas, and composed of Boussingault, Bouley, Jamin, Daubrée, Bertin, Tisserand, and Davaine, arrived at the Ecole Normale and found Pasteur in the midst of his family.

"My dear Pasteur," said Dumas, in his deep voice, "forty years ago, you entered this building as a student. From the very first, your masters foresaw that you would be an honour to it, but no one would have dared to predict the startling services which you were destined to render to science, France, and the world."

And after summing up in a few words Pasteur's great career, the sources of wealth which he had discovered or revived, the benefits he had acquired to medicine and surgery : "My dear Pasteur," continued Dumas, with an affectionate emotion, "your life has known but success. The scientific method which you use in such a masterly manner owes you its greatest triumphs. The Ecole Normale is proud to number you amongst its pupils; the Académie des Sciences is proud of your work; France ranks you amongst its glories.

"At this time, when marks of public gratitude are flowing towards you from every quarter, the homage which we have come to offer you, in the name of your admirers and friends, may seem worthy of your particular attention. It emanates from a spontaneous and universal feeling, and it will preserve for posterity the faithful likeness of your features.

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" May you, my dear Pasteur, long live to enjoy your fame, and to contemplate the rich and abundant fruit of your work. Science, agriculture, industry, and humanity, will preserve eternal gratitude towards you, and your name will live in their annals amongst the most illustrious and the most revered."

Pasteur, standing with bowed head, his eyes full of tears, was for a few moments unable to reply, and then, making a violent effort, he said in a low voice—

" My dear master—it is indeed forty years since I first had the happiness of knowing you, and since you first taught me to love science.

" I was fresh from the country ; after each of your classes, I used to leave the Sorbonne transported, often moved to tears. From that moment, your talent as a professor, your immortal labours and your noble character have inspired me with an admiration which has but grown with the maturity of my mind.

" You have surely guessed my feelings, my dear master. There has not been one important circumstance in my life or in that of my family, either happy or painful, which you have not, as it were, blessed by your presence and sympathy.

" Again to-day, you take the foremost rank in the expression of that testimony, very excessive, I think, of the esteem of my masters, who have become my friends. And what you have done for me, you have done for all your pupils; it is one of the distinctive traits of your nature. Behind the individual, you have always considered France and her greatness.

" What shall I do henceforth? Until now, great praise had inflamed my ardour, and only inspired me with the idea of making myself worthy of it by renewed efforts ; but that which you have just given me in the names of the

Académie and of the Scientific Societies is in truth beyond my courage."

Pasteur, who for a year had been applauded by the crowd, received on that June 25, 1882, the testimony which he rated above every other: praise from his master.

Whilst he recalled the beneficent influence which Dumas had had over him, those who were sitting in his drawing-room at the Ecole Normale were thinking that Dumas might have evoked similar recollections with similar charm. He too had known enthusiasms which had illumined his youth. In 1822, the very year when Pasteur was born, Dumas, who was then living in a student's attic at Geneva, received the visit of a man about fifty, dressed Directoire fashion, in a light blue coat with steel buttons, a white waistcoat and yellow breeches. It was Alexander von Humboldt, who had wished, on his way through Geneva, to see the young man who, though only twenty-two years old, had just published, in collaboration with Prévost, treatises on blood and on urea. That visit, the long conversations, or rather the monologues, of Humboldt had inspired Dumas with the feelings of surprise, pride, gratitude and devotion with which the first meeting with a great man is wont to fill the heart of an enthusiastic youth. When Dumas heard Humboldt speak of Laplace, Berthollet, Gay-Lussac, Arago, Thenard, Cuvier, etc., and describe them as familiarly accessible, instead of as the awe-inspiring personages he had imagined, Dumas became possessed with the idea of going to Paris, knowing those men, living near them and imbibing their methods. "On the day when Humboldt left Geneva," Dumas used to say, "the town for me became empty." It was thus that Dumas' journey to Paris was decided on, and his dazzling career of sixty years begun.

He was now near the end of his scientific career, closing

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peacefully like a beautiful summer evening, and he was happy in the fame of his former pupil. As he left the Ecole Normale, on that June afternoon, he passed under the windows of the laboratory, where a few young men, imbued with Pasteur's doctrines, represented a future reserve for the progress of science.

That year 1882 was the more interesting in Pasteur's life, in that though victory on many points was quite indisputable, partial struggles still burst out here and there, and an adversary often arose suddenly when he had thought the engagement over.

The sharpest attacks came from Germany. The Record of the Works of the German Sanitary Office had led, under the direction of Dr. Koch and his pupils, a veritable campaign against Pasteur, whom they declared incapable of cultivating microbes in a state of purity. He did not even, they said, know how to recognize the septic vibrio, though he had discovered it. The experiments by which hens contracted splenic fever under a lowered temperature after inoculation signified nothing. The share of the earth-worms in the propagation of charbon, the inoculation into guinea-pigs of the germs found in the little cylinders produced by those worms followed by the death of the guinea-pigs, all this they said was pointless and laughable. They even contested the preserving influence of vaccination.

Whilst these things were being said and written, the Veterinary School of Berlin asked the laboratory of the Ecole Normale for some charbon vaccine. Pasteur answered that he wished that experiments should be made before a commission nominated by the German Government. It was constituted by the Minister of Agriculture and Forests, and Virchow was one of the members of it. A former student of the Ecole Normale—

who, after leaving the school first on the list of competitors for the *agrégation* of physical science, had entered the laboratory—one in whom Pasteur founded many hopes, Thuillier, left for Germany with his little tubes of attenuated virus. Pasteur was not satisfied; he would have liked to meet his adversaries face to face and oblige them publicly to own their defeat. An opportunity was soon to arise. He had come to Arbois, as usual, for the months of August and September, and was having some alterations made in his little house. The tannery pits were being filled up. "It will not improve the house itself," he wrote to his son, "but it will be made brighter and more comfortable by having a tidy yard and a garden along the riverside."

The Committee of the International Congress of Hygiene, which was to meet at Geneva, interrupted these peaceful holidays, by inviting Pasteur to read a paper on attenuated virus. As a special compliment, the whole of one meeting, that of the Tuesday, September 5, was to be reserved for his paper only. Pasteur immediately returned to work; he only consented under the greatest pressure, to go for a short walk on the Besançon road at five o'clock every afternoon. After spending the whole morning and the whole afternoon sitting at his writing table over laboratory registers, he came away grumbling at being disturbed in his work. If any member of his family ventured a question on the proposed paper, he hastily cut them short, declaring that he must be let alone. It was only when Mme. Pasteur had copied out in her clear handwriting all the little sheets covered with footnotes, that the contents of the paper became known.

When Pasteur entered the Congress Hall, great applause greeted him on every side. The seats were occupied, not only by the physicians and professors who form the usual

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audience of a congress, but also by tourists, who take an interest in scientific things when they happen to be the fashion.

Pasteur spoke of the invitation he had received. "I hastened to accept it," he said, "and I am pleased to find myself the guest of a country which has been a friend to France in good as in evil days. Moreover, I hoped to meet here some of the contraditors of my work of the last few years. If a congress is a ground for conciliation, it is in the same degree a ground for courteous discussion. We all are actuated by a supreme passion, that of progress and of truth."

Almost always, at the opening of a congress, great politeness reigns in a confusion of languages. Men are seen offering each other pamphlets, exchanging visiting cards, and only lending an inattentive ear to the solemn speeches going on. This time, the first scene of the first act suspended all private conversation. Pasteur stood above the assembly in his full strength and glory. Though he was almost sixty, his hair had remained black, his beard alone was turning grey. His face reflected indomitable energy; if he had not been slightly lame, and if his left hand had not been a little stiff, no one could have supposed that he had been struck with paralysis fourteen years before. The feeling of the place France should hold in an International Congress gave him a proud look and an imposing accent of authority. He was visibly ready to meet his adversaries and to make of this assembly a tribunal of judges. Except for a few diplomats who at the first words exchanged anxious looks at the idea of possible polemics, Frenchmen felt happy at being better represented than any other nation. Men eagerly pointed out to each other Dr. Koch, twenty-one years younger than Pasteur, who sat on one of the benches, listening, with impulsive eyes behind his gold spectacles.

Pasteur analysed all the work he had done with the collaboration of MM. Chamberland, Roux, and Thuillier. He made clear to the most ignorant among his hearers his ingenious experiments either to obtain, preserve or modify the virulence of certain microbes. "It cannot be doubted," he said, "that we possess a general method of attenuation. . . . The general principles are found, and it cannot be disbelieved that the future of those researches is rich with the greatest hopes. But, however obvious a demonstrated truth may be, it has not always the privilege of being easily accepted. I have met in France and elsewhere with some obstinate contradicitors. . . . Allow me to choose amongst them the one whose personal merit gives him the greatest claims to our attention, I mean Dr. Koch, of Berlin."

Pasteur then summed up the various criticisms which had appeared in the Record of the Works of the German Sanitary Office. "Perhaps there may be some persons in this assembly," he went on, "who share the opinions of my contradicitors. They will allow me to invite them to speak; I should be happy to answer them."

Koch, mounting the platform, declined to discuss the subject, preferring, he said, to make answer in writing later on. Pasteur was disappointed; he would have wished the congress, or at least a Commission designated by Koch, to decide on the experiments. He resigned himself to wait. On the following days, as the members of the Congress saw him attending meetings on general hygiene, school hygiene, and veterinary hygiene, they hardly recognized in the simple, attentive man, anxious for instruction, the man who had defied his adversary. Outside the arena, Pasteur became again the most modest of men, never allowing himself to criticize what he had not thoroughly studied. But, when sure of his facts, he showed himself

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full of a violent passion, the passion of truth; when truth had triumphed, he preserved not the least bitterness of former struggles.

That day of the 5th September was remembered in Geneva. "All the honour was for France," wrote Pasteur to his son; "that was what I had wished."

He was already keen in the pursuit of another malady which caused great damage, the "rouget" disease or swine fever. Thuillier, ever ready to start when a demonstration had to be made or an experiment to be attempted, had ascertained, in March, 1882, in a part of the Department of the Vienne, the existence of a microbe in the swine attacked with that disease.

In order to know whether this microbe was the cause of the evil, the usual operations of the sovereign method had to be resorted to. First of all, a culture medium had to be found which was suitable to the micro-organism (veal broth was found to be very successful); then a drop of the culture had to be abstracted from the little phials where the microbe was developing and sown into other flasks; lastly the culture liquid had to be inoculated into swine. Death supervened with all the symptoms of swine fever; the microbe was therefore the cause of the evil. Could it be attenuated and a vaccine obtained? Being pressed to study that disease, and to find the remedy for it, by M. Maucuer, a veterinary surgeon of the Department of Vaucluse, living at Bollène, Pasteur started, accompanied by his nephew, Adrien Loir, and M. Thuillier. The three arrived at Bollène on September 13.

"It is impossible to imagine more obliging kindness than that of those excellent Maucuers," wrote Pasteur to his wife the next day. "Where, in what dark corner they sleep, in order to give us two bedrooms, mine and another

with two beds, I do not like to think. They are young, and have an eight-year-old son at the Avignon College, for whom they have obtained a half-holiday to-day in order that he may be presented to 'M. Pasteur.' The two men and I are taken care of in a manner you might envy. It is colder here and more rainy than in Paris. I have a fire in my room, that green oak-wood fire that you will remember we had at the Pont Gisquet.

"I was much pleased to hear that the swine fever is far from being extinguished. There are sick swine everywhere, some dying, some dead, at Bollène and in the country around; the evil is disastrous this year. We saw some dead and dying yesterday afternoon. We have brought here a young hog who is very ill, and this morning we shall attempt vaccination at a M. de Ballincourt's, who has lost all his pigs, and who hast just bought some more in the hope that the vaccine will be preservative. From morning till night we shall be able to watch the disease and to try to prevent it. This reminds me of the pébrine, with pigsties and sick pigs instead of nurseries full of dying silkworms. Not ten thousand, but at least twenty thousand swine have perished, and I am told it is worse still in the Ardèche."

On the 17th, the day was taken up by the inoculation of some pigs on the estate of a M. de la Gardette, a few kilomètres from Bollène. In the evening, a former State Counsellor, M. de Gaillard, came at the head of a delegation to compliment Pasteur and invite him to a banquet. Pasteur declined this honour, saying he would accept it when the swine fever was conquered. They spoke to him of his past services, but he had no thought for them; like all progress-seeking men, he saw but what was before him. Experiments were being carried out—he had hastened to have an experimental pigsty erected near M. Maucuer's house—

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and already, on the 21st, he wrote to Mme. Pasteur, in one of those letters which resembled the loose pages of a laboratory notebook—

“Swine fever is not nearly so obscure to me now, and I am persuaded that with the help of time the scientific and practical problem will be solved.

“Three post-mortem examinations to-day. They take a long time, but that seems of no account to Thuillier, with his cool and patient eagerness.”

Three days later: “I much regret not being able to tell you yet that I am starting back for Paris. It is quite impossible to abandon all these experiments which we have commenced; I should have to return here at least once or twice. The chief thing is that things are getting clearer with every experiment. You know that nowadays a medical knowledge of disease is nothing; it must be prevented beforehand. We are attempting this, and I think I can foresee success; but keep this for yourself and our children. I embrace you all most affectionately.

“P.S.—I have never felt better. Send me 1,000 fr.; I have but 300 fr. left of the 1,600 fr. I brought. Pigs are expensive, and we are killing a great many.”

At last on December 3: “I am sending M. Dumas a note for to-morrow’s meeting at the Academy. If I had time I would transcribe it for the laboratory and for René.”

“Our researches”—thus ran the report to the Academy—“may be summed up in the following propositions—

“I. The swine fever, or rouget disease, is produced by a special microbe, easy to cultivate outside the animal’s body. It is so tiny that it often escapes the most attentive search. It resembles the microbe of chicken cholera more than any other; its shape is also that of a figure 8, but finer and less visible than that of the cholera. It differs essentially

from the latter by its physiological properties; it kills rabbits and sheep, but has no effect on hens.

"II. If inoculated in a state of purity into pigs, in almost inappreciable doses, it speedily brings the fever and death, with all the characteristics usual in *spontaneous* cases. It is most deadly to the white, so-called improved, race, that which is most sought after by pork-breeders.

"III. Dr. Klein published in London (1878) an extensive work on swine fever, which he calls *Pneumo-enteritis of Swine*; but that author is entirely mistaken as to the nature of the parasite. He has described as the microbe of the rouget a bacillus with spores, more voluminous even than the bacteridium of splenic fever. Dr. Klein's microbe is very different from the true microbe of swine fever, and has, besides, no relation to the etiology of that disease.

"IV. After having satisfied ourselves by direct tests that the malady does not recur, we have succeeded in inoculating it in a benignant form, after which the animal has proved refractory to the mortal disease.

"V. Though we consider that further control experiments are necessary, we have already great confidence in this, that, dating from next spring, vaccination by the virulent microbe of swine fever, attenuated, will become the salvation of pigsties."

Pasteur ended thus his letter of December 3: "We shall start to-morrow, Monday. Adrien Loir and I shall sleep at Lyons. Thuillier will go straight to Paris, to take care of ten little pigs which we have bought, and which he will take with him. In this way they will not be kept waiting at stations. Pigs, young and old, are very sensitive to cold; they will be wrapped up in straw. They are very young and quite charming; one cannot help getting fond of them."

The next day Pasteur wrote to his son: "Everything

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has gone off well, and we much hope, Thuillier and I, that preventive vaccination of this evil can be established in a practical fashion. It would be a great boon in pork-breeding countries, where terrible ravages are made by the rouget (so called because the animals die covered with red or purple blotches, already developed during the fever which precedes death). In the United States, over a million swine died of this disease in 1879; it rages in England and in Germany. This year, it has desolated the Côtes-du-Nord, the Poitou, and the departments of the Rhone Valley. I sent to M. Dumas yesterday a *résumé* in a few lines of our results, to be read at to-day's meeting."

Pasteur, once more in Paris, returned eagerly to his studies on divers virus and on hydrophobia. If he was told that he over-worked himself, he replied: "It would seem to me that I was committing a theft if I were to let one day go by without doing some work." But he was again disturbed in the work he enjoyed by the contradictions of his opponents.

Koch's reply arrived soon after the Bollène episode. The German scientist had modified his views to a certain extent; instead of denying the attenuation of virus as in 1881, he now proclaimed it as a discovery of the first order. But he did not believe much, he said, in the practical results of the vaccination of charbon.

Pasteur put forward in response, a report from the veterinary surgeon Boutet to the Chartres Veterinary and Agricultural School, made in the preceding October. The sheep vaccinated in Eure et Loir during the last year formed a total of 79,392. Instead of a mortality which had been more than nine per cent. on the average in the last ten years, the mortality had only been 518 sheep, much less than one per cent.; 5,700 sheep had therefore been preserved by vaccination. Amongst cattle 4,562 animals had been

vaccinated; out of a similar number 300 usually died every year. Since vaccination, only eleven cows had died.

"Such results appear to us convincing," wrote M. Boutet. "If our cultivators of the Beauce understand their own interest, splenic fever and malignant pustules will soon remain a mere memory, for charbon diseases never are spontaneous, and, by preventing the death of their cattle by vaccination, they will destroy all possibility of propagation of that terrible disease, which will in consequence entirely disappear."

Koch continued to smile at the discovery on the earth-worms' action in the etiology of anthrax. "You are mistaken, Sir," replied Pasteur. "You are again preparing for yourself a vexing change of opinion." And he concluded as follows: "However violent your attacks, Sir, they will not hinder the success of the method of attenuated virus. I am confidently awaiting the consequences which it holds in reserve to help humanity in its struggle against the diseases which assault it."

This debate was hardly concluded when new polemics arose at the Académie de Médecine. A new treatment of typhoid fever was under discussion.

In 1870, M. Glénard, a Lyons medical student, who had enlisted, was, with many others, taken to Stettin as prisoner of war. A German physician, Dr. Brand, moved with compassion by the sufferings of the vanquished French soldiers, showed them great kindness and devotion. The French student attached himself to him, helped him with his work, and saw him treat typhoid fever with success by baths at 20° C. Brand prided himself on this cold bath treatment, which produced numerous cures. M. Glénard, on his return, to Lyons, remembering with confidence this method of which he had seen the excellent results, persuaded the physician of the Croix Rousse hospital, where he resided, to

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attempt the same treatment. This was done for ten years, and nearly all the Lyons practitioners became convinced that Brand's method was efficacious. M. Glénard came to Paris and read to the Academy of Medicine a paper on the cold-bath treatment of typhoid fever. The Academy appointed a commission, composed of civil and military physicians, and the discussion was opened.

The oratorical display which had struck Pasteur when he first came to the Académie de Médecine was much to the fore on that occasion; the merely curious hearers of that discussion had an opportunity of enjoying medical eloquence, besides acquiring information on the new treatment of typhoid fever. There were some vehement denunciations of the microbe which was suspected in typhoid fever. "You aim at the microbe and you bring down the patient!" exclaimed one of the orators, who added, amidst great applause, that it was time "to offer an impassable barrier to such adventurous boldness, and thus to preserve patients from the unforeseen dangers of that therapeutic whirlwind!"

Another orator took up a lighter tone: "I do not much believe in that invasion of parasites which threatens us like an eleventh plague of Egypt," said M. Peter. And attacking the scientists who meddled with medicine, *chymasters* as he called them, "They have come to this," he said, "that in typhoid fevers they only see *the* typhoid fever, in typhoid fever, fever only, and in fever, increased heat. They have thus reached that luminous idea that heat must be fought by cold. This organism is on fire, let us pour water over it; it is a fireman's doctrine."

Vulpian, whose grave mind was not unlike Pasteur's, intervened, and said that new attempts should not be discouraged by sneers. Without pronouncing on the merits of the cold-bath method, which he had not tried, he looked

beyond this discussion, indicating the road which theoretically seemed to him to lead to a curative treatment. The first thing was to discover the agent which causes typhoid fever, and then, when that was known, attempt to destroy or paralyse it in the tissues of typhoid patients, or else to find drugs capable either of preventing the aggressions of that agent or of annihilating the effects of that aggression, "to produce, relatively to typhoid fever, the effect determined by salicylate of soda in acute rheumatism of the articulations."

Beyond the restricted audience, allowed a few seats in the Académie de Médecine, the general public itself was taking an interest in this prolonged debate. The very high death rate in the army due to typhoid fever was the cause of this eager attention. Whilst the German army, where Brand's method was employed, hardly lost five men out of a thousand, the French army lost more than ten per thousand.

Whilst military service was not compulsory, epidemics in barracks were looked upon with more or less compassionate attention. But the thought that typhoid fever had been more destructive within the last ten years than the most sanguinary battle, now awakened all minds and hearts. Is then personal fear necessary to awaken human compassion?

Bouley, who was more given to propagating new doctrines than to lingering on such philosophical problems, thought it was time to introduce into the debate certain ideas on the great problems tackled by medicine since the discovery of what might be called a fourth kingdom in nature, that of microbia. In a statement read at the Académie de Médecine, he formulated in broad lines the rôle of the infinitesimally small and their activity in producing the phenomena of fermentations and diseases. He

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showed by the parallel works of Pasteur on the one hand, and M. Chauveau on the other, that contagion is the function of a living element. "It is especially," said Bouley, "on the question of the prophylaxis of virulent diseases that the microbian doctrine has given the most marvellous results. To seize upon the most deadly virus, to submit them to a methodical culture, to cause modifying agents to act upon them in a measured proportion, and thus to succeed in attenuating them in divers degrees, so as to utilize their strength, reduced but still efficacious, in transmitting a benignant malady by means of which immunity is acquired against the deadly disease: what a beautiful dream!! And M. Pasteur has made that dream into a reality!!! . . ."

The debate widened, typhoid fever became a mere incident. The pathogenic action of the infinitesimally small entered into the discussion; traditional medicine faced microbian medicine. M. Peter rushed once more to the front rank for the fight. He declared that he did not apply the term *chymia* to Pasteur; he recognized that it was but "fair to proclaim that we owe to M. Pasteur's researches the most useful practical applications in surgery and in obstetrics." But considering that medicine might claim more independence, he repeated that the discovery of the material elements of virulent diseases did not throw so much light as had been said, either on pathological anatomy, on the evolution, on the treatment or especially on the prophylaxis of virulent diseases. "Those are but natural history curiosities," he added, "interesting no doubt, but of very little profit to medicine, and not worth either the time given to them or the noise made about them. After so many laborious researches, nothing will be changed in medicine, there will only be a few more microbes."

A newspaper having repeated this last sentence, a professor of the Faculty of Medicine, M. Cornil, simply recalled how, at the time when the acarus of itch had been discovered, many partisans of old doctrines had probably exclaimed, "What is your acarus to me? Will it teach me more than I know already?" "But," added M. Cornil, "the physician who had understood the value of that discovery no longer inflicted internal medication upon his patients to cure them of what seemed an inveterate disease, but merely cured them by means of a brush and a little ointment."

M. Peter, continuing his violent speech, quoted certain vaccination failures, and incompletely reported experiments, saying, grandly: "M. Pasteur's excuse is that he is a chemist, who has tried, out of a wish to be useful, to reform medicine, to which he is a complete stranger. . . .

"In the struggle I have undertaken the present discussion is but a skirmish; but, to judge from the reinforcements which are coming to me, the *mêlée* may become general, and victory will remain, I hope, to the larger battalions, that is to say, to the 'old medicine.'"

Bouley, amazed that M. Peter should thus scout the notion of microbia introduced into pathology, valiantly fought this "skirmish" alone. He recalled the discussions à propos of tuberculosis, so obscure until a new and vivifying notion came to simplify the solution of the problem. "And you reject that solution! You say, 'What does it matter to me?' . . . What! M. Koch, of Berlin—who with such discoveries as he has made might well abstain from envy—M. Koch points out to you the presence of bacteria in tubercles, and that seems to you of no importance? But that microbe gives you the explanation of those contagious properties of tuberculosis so well demonstrated by M. Villemin, for it is the instrument of virulence itself which is put under your eyes."

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Bouley then went on to refute the arguments of M. Peter, epitomized the history of the discovery of the attenuation of virus, and all that this method of cultures possible in an extra-organic medium might suggest that was hopeful for a vaccine of cholera and of yellow fever, which might be discovered one day and protect humanity against those terrible scourges. He concluded thus—"Let M. Peter do what I have done; let him study M. Pasteur, and penetrate thoroughly into all that is admirable, through the absolute certainty of the results, in the long series of researches which have led him from the discovery of ferments to that of the nature of virus; and then I can assure him that instead of decrying this great glory of France, of whom we must all be proud, he too will feel himself carried away by enthusiasm and will bow with admiration and respect before the chemist, who, though not a physician, illuminates medicine and dispels, in the light of his experiments, a darkness which had hitherto remained impenetrable."

A year before this (Peter had not failed to report the fact) an experiment of anthrax vaccination had completely failed at the Turin Veterinary School. All the sheep, vaccinated and non-vaccinated, had succumbed subsequently to the inoculation of the blood of a sheep which had died of charbon.

This took place in March, 1882. As soon as Pasteur heard of this extraordinary fiasco, which seemed the counterpart of the Pouilly-le-Fort experiment, he wrote on April 16 to the director of the Turin Veterinary School, asking on what day the sheep had died the blood of which had been used for the virulent inoculation.

The director answered simply that the sheep had died on the morning of March 22, and that its blood had been inoculated during the course of the following day. "There has been," said Pasteur, "a grave scientific mistake;

the blood inoculated was septic as well as full of charbon."

Though the director of the Turin Veterinary School affirmed that the blood had been carefully examined and that it was in no wise septic, Pasteur looked back on his 1877 experiments on anthrax and septicæmia, and maintained before the Paris Central Veterinary Society on June 8, 1882, that the Turin School had done wrong in using the blood of an animal at least twenty-four hours after its death, for the blood must have been septic besides containing anthrax. The six professors of the Turin School protested unanimously against such an interpretation. "We hold it marvellous," they wrote ironically, "that your Illustrious Lordship should have recognized so surely, from Paris, the disease which made such havoc amongst the animals vaccinated and non-vaccinated and inoculated with blood containing anthrax in our school on March 23, 1882.

"It does not seem to us possible that a scientist should affirm the existence of septicæmia in an animal he has not even seen. . . ."

The quarrel with the Turin School had now lasted a year. On April 9, 1883, Pasteur appealed to the Academy of Science to judge of the Turin incident and to put an end to this agitation, which threatened to cover truth with a veil. He read out the letter he had just addressed to the Turin professors.

"Gentlemen, a dispute having arisen between you and myself respecting the interpretation to be given to the absolute failure of your control experiment of March 23, 1882, I have the honour to inform you that, if you will accept the suggestion, I will go to Turin any day you may choose; you shall inoculate in my presence some virulent charbon into any number of sheep you like. The exact

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moment of death in each case shall be determined, and I will demonstrate to you that in every case the blood of the corpse containing only charbon at the first will also be septic on the next day. It will thus be established with absolute certainty that the assertion formulated by me on June 8, 1882, against which you have protested on two occasions, arises, not as you say, from an arbitrary opinion, but from an immovable scientific principle; and that I have legitimately affirmed from Paris, the presence of septicæmia without it being in the least necessary that I should have seen the corpse of the sheep you utilized for your experiments.

"Minutes of the facts as they are produced shall be drawn up day by day, and signed by the professors of the Turin Veterinary School and by the other persons, physicians or veterinary surgeons who may have been present at the experiments; these minutes will then be published both at the Academies of Turin and of Paris."

Pasteur contented himself with reading this letter to the Academy of Sciences. For months he had not attended the Academy of Medicine; he was tired of incessant and barren struggles; he often used to come away from the discussions worn out and excited. He would say to Messrs. Chamberland and Roux, who waited for him after the meetings, "How is it that certain doctors do not understand the range, the value, of our experiments? How is it that they do not foresee the great future of all these studies?"

The day after the Académie des Sciences meeting, judging that his letter to Turin sufficiently closed the incident, Pasteur started for Arbois. He wanted to set up a laboratory adjoining his house. Where the father had worked with his hands, the son would work at his great light-emitting studies.

On April 3 a letter from M. Peter had been read at the

Academy of Medicine, declaring that he did not give up the struggle and that nothing would be lost by waiting.

At the following sitting, another physician, M. Fauvel, while declaring himself an admirer of Pasteur's work and full of respect for his person, thought it well not to accept blindly all the inductions into which Pasteur might find himself drawn, and to oppose those which were contradictory to acquired facts. After M. Fauvel, M. Peter violently attacked what he called "microbicidal drugs which may become homicidal," he said. When reading the account of this meeting, Pasteur had an impulse of anger. His resolutions not to return to the Academy of Medicine gave way before the desire not to leave Bouley alone to lead the defensive campaign ; he started for Paris.

As his family was then at Arbois, and the doors of his flat at the Ecole Normale closed, the simplest thing for Pasteur was to go to the Hôtel du Louvre, accompanied by a member of his family. The next morning he carefully prepared his speech, and, at three o'clock in the afternoon, he entered the Academy of Medicine. The President, M. Hardy, welcomed him in these words—"Allow me, before you begin to speak, to tell you that it is with great pleasure that we see you once again among us, and that the Academy hopes that, now that you have once more found your way to its precincts, you will not forget it again."

After isolating and rectifying the points of discussion, Pasteur advised M. Peter to make a more searching inquiry into the subject of anthrax vaccination, and to trust to Time, the only sovereign judge. Should not the recollection of the violent hostility encountered at first by Jenner put people on their guard against hasty judgments? There was not one of the doctors present who could not remember what had been written at one time against vaccination !!!

He went on to oppose the false idea that each science

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should restrict itself within its own limitations. "What do I, a physician, says M. Peter, want with the minds of the chemist, the physicist and the physiologist ?

"On hearing him speak with so much disdain of the chemists and physiologists who touch upon questions of disease, you might verily think that he is speaking in the name of a science whose principles are founded on a rock ! Does he want proofs of the slow progress of therapeutics ? It is now six months since, in this assembly of the greatest medical men, the question was discussed whether it is better to treat typhoid fever with cold lotions or with quinine, with alcohol or salicylic acid, or even not to treat it at all.

"And, when we are perhaps on the eve of solving the question of the etiology of that disease by a microbe, M. Peter commits the medical blasphemy of saying, 'What do your microbes matter to me ? It will only be one microbe the more !'"

Amazed that sarcasm should be levelled against new studies which opened such wide horizons, he denounced the flippancy with which a professor of the Faculty of Medicine allowed himself to speak of vaccinations by attenuated virus.

He ended by rejoicing once more that this great discovery should have been a French one.

Pasteur went back to Arbois for a few days. On his return to Paris, he was beginning some new experiments, when he received a long letter from the Turin professors. Instead of accepting his offer, they enumerated their experiments, asked some questions in an offended and ironical manner, and concluded by praising an Italian national vaccine, which produced absolute immunity in the future—when it did not kill.

"They cannot get out of this dilemma," said Pasteur; "either they knew my 1877 notes, unravelling the contradictory statements of Davaine, Jaillard and Leplat, and Paul Bert, or they did not know them. If they did not know them on March 22, 1882, there is nothing more to say; they were not guilty in acting as they did, but they should have owned it freely. If they did know them, why ever did they inoculate blood taken from a sheep twenty-four hours after its death? They say that this blood was not septic; but how do they know? They have done nothing to find out. They should have inoculated some guinea-pigs, by choice, and then tried some cultures in a vacuum to compare them with cultures in contact with air. Why will they not receive me? A meeting between truth-seeking men would be the most natural thing in the world!"

Still hoping to persuade his adversaries to meet him at Turin and be convinced, Pasteur wrote to them. "*Paris, May 9, 1883.* Gentlemen—Your letter of April 30 surprises me very much. What is in question between you and me? That I should go to Turin, if you will allow me, to demonstrate that sheep, dead of charbon, as numerous as you like, will, for a few hours after their death, be exclusively infected with anthrax, and that the day after their death they will present both anthrax and septic infection; and that therefore, when, on March 23, 1882, wishing to inoculate blood infected with anthrax only into sheep vaccinated and non-vaccinated, you took blood from a carcase twenty-four hours after death, you committed a grave scientific mistake.

"Instead of answering yes or no, instead of saying to me 'Come to Turin,' or 'Do not come,' you ask me in a manuscript letter of seventeen pages, to send you from Paris, in writing, preliminary explanations of all that I should have to demonstrate in Turin.

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"Really, what is the good? Would not that lead to endless discussions? It is because of the uselessness of a written controversy that I have placed myself at your disposal.

"I have once more the honour of asking you to inform me whether you accept the proposal made to you on April 9, that I should go to Turin to place before your eyes the proofs of the facts I have just mentioned.

"PS.—In order not to complicate the debate, I do not dwell upon the many erroneous quotations and statements contained in your letter."

M. Roux began to prepare an interesting curriculum of experiments to be carried out at Turin. But the Turin professors wrote a disagreeable letter, published a little pamphlet entitled, *Of the Scientific Dogmatism of the Illustrious Professor Pasteur*, and things remained as they were.

All these discussions, renewed on so many divers points, were not altogether a waste of time; some of them bore fruitful results by causing most decisive proofs to be sought for. It has also made the path of Pasteur's followers wider and smoother that he himself should have borne the brunt of the first opposition.

In the meanwhile, testimonials of gratitude continued to pour in from the agricultors and veterinary surgeons who had seen the results of two years' practice of the vaccination against anthrax.

In the year 1882, 613,740 sheep and 83,946 oxen had been vaccinated. The Department of the Cantal which had before lost about 3,000,000 fr. every year, desired in June, 1883, on the occasion of an agricultural show, to give M. Pasteur a special acknowledgement of their gratitude. It consisted of a cup of silver-plated bronze, ornamented with a group of cattle. Behind the group—imitating in

this the town of Aubenas, who had made a microscope figure as an attribute of honour—was represented, in small proportions, an instrument which found itself for the first time raised to such an exalted position, the little syringe used for inoculations.

Pasteur was much pressed to come himself and receive this offering from a land which would henceforth owe its fortune to him. He allowed himself to be persuaded, and arrived, accompanied as usual by his family.

The Mayor, surrounded by the municipal councillors, greeted him in these words: "Our town of Aurillac is very small, and you will not find here the brilliant population which inhabits great cities; but you will find minds capable of understanding the scientific and humanitarian mission which you have so generously undertaken. You will also find hearts capable of appreciating your benefits and of preserving the memory of them; your name has been on all our lips for a long time."

Pasteur, visiting that local exhibition, did not resemble the official personages who listen wearily to the details given them by a staff of functionaries. He thought but of acquiring knowledge, going straight to this or that exhibitor and questioning him, not with perfunctory politeness, but with a real desire for practical information; no detail seemed to him insignificant. "Nothing should be neglected," he said; "and a remark from a rough labourer who does well what he has to do is infinitely precious."

After visiting the products and agricultural implements, Pasteur was met in the street by a peasant who stopped and waved his large hat, shouting, "Long live Pasteur!" . . . "You have saved my cattle," continued the man, coming up to shake hands with him.

Physicians in their turn desired to celebrate and to honour him who, though not a physician, had rendered such

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service to medicine. Thirty-two of them assembled to drink his health. The head physician of the Aurillac Hospital, Dr. Fleys, said in proposing the toast: "What the mechanism of the heavens owes to Newton, chemistry to Lavoisier, geology to Cuvier, general anatomy to Bichat, physiology to Claude Bernard, pathology and hygiene will owe to Pasteur. Unite with me, dear colleagues, and let us drink to the fame of the illustrious Pasteur, the precursor of the medicine of the future, a benefactor to humanity."

This glorious title was now associated with his name. In the first rank of his enthusiastic admirers came the scientists, who, from the point of view of pure science, admired the achievements, within those thirty-five years, of that great man whose perseverance equalled his penetration. Then came the manufacturers, the sericultors, and the agricultors, who owed their fortune to him who had placed every process he discovered into the public domain. Finally, France could quote the words of the English physiologist, Huxley, in a public lecture at the London Royal Society: "Pasteur's discoveries alone would suffice to cover the war indemnity of five milliards paid by France to Germany in 1870."

To that capital was added the inestimable price of human lives saved. Since the antiseptic method had been adopted in surgical operations, the mortality had fallen from 50 per 100 to 5 per 100.

In the lying-in hospitals, more than decimated formerly, (for the statistics had shown a death-rate of not only 100 but 200 per 1,000), the number of fatalities was now reduced to 3 per 1,000 and soon afterwards fell to 1 per 1,000. And, in consequence of the principles established by Pasteur, hygiene was growing, developing, and at last

taking its proper place in the public view. So much progress accomplished had brought Pasteur a daily growing acknowledgement of gratitude, his country was more than proud of him. His powerful mind, allied with his very tender heart, had brought to French glory an aureole of charity.

The Government of the Republic remembered that England had voted two national rewards to Jenner, one in 1802 and one in 1807, the first of £10,000, and the second of £20,000. It was at the time of that deliberation that Pitt, the great orator, exclaimed, "Vote, gentlemen, your gratitude will never reach the amount of the service rendered."

The French ministry proposed to augment the 12,000 fr. pension accorded to Pasteur in 1874 as a national recompence, and to make it 25,000 fr., to revert first to Pasteur's widow, and then to his children. A Commission was formed and Paul Bert again chosen to draw up the report.

On several occasions at the meetings of the commission one of its members, Benjamin Raspail, exalted the parasitic theory propounded in 1843 by his own father. His filial pleading went so far as to accuse Pasteur of plagiarism. Paul Bert, whilst recognizing the share attributed by F. V. Raspail to microscopic beings, recalled the fact that his attempt in favour of epidemic and contagious diseases had not been adopted by scientists. "No doubt," he said, "the parasitic origin of the itch was now definitely accepted, thanks in a great measure to the efforts of Raspail; but generalizations were considered as out of proportion to the fact they were supposed to rest on. It seemed excessive to conclude from the existence of the acarus of itch, visible to the naked eye or with the weakest magnifying glass, the presence of microscopic

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parasites in the humours of virulent diseases. . . . Such hypotheses can be considered but as a sort of intuition."

"Hypotheses," said Pasteur, "come into our laboratories in armfuls; they fill our registers with projected experiments, they stimulate us to research — and that is all." One thing only counted for him: experimental verification.

Paul Bert, in his very complete report, quoted Huxley's words to the Royal Society and Pitt's words to the House of Commons. He stated that since the first Bill had been voted, a new series of discoveries, no less marvellous from a theoretical point of view and yet more important from a practical point of view, had come to strike the world of Science with astonishment and admiration." Recapitulating Pasteur's works, he said—

"They may be classed in three series, constituting three great discoveries.

"The first one may be formulated thus: *Each fermentation is produced by the development of a special microbe.*

"The second one may be given this formula: *Each infectious disease (those at least that M. Pasteur and his immediate followers have studied) is produced by the development within the organism of a special microbe.*

"The third one may be expressed in this way: *The microbe of an infectious disease, cultivated under certain detrimental conditions, is attenuated in its pathogenic activity; from a virus it has become a vaccine.*"

"As a practical consequence of the first discovery, M. Pasteur has given rules for the manufacture of beer and of vinegar, and shown how beer and wine may be preserved against secondary fermentations which would turn them sour, bitter, or slimy, and which render difficult their transport and even their preservation on the spot.

"As a practical consequence of the second discovery, M. Pasteur has given rules to be followed to preserve cattle from splenic fever contamination, and silkworms from the diseases which decimated them. Surgeons, on the other hand, have succeeded, by means of the guidance it afforded, in effecting almost completely the disappearance of erysipelas and of the purulent infections which formerly brought about the death of so many patients after operations.

"As a practical consequence of the third discovery, M. Pasteur has given rules for, and indeed has effected, the preservation of horses, oxen, and sheep from the anthrax disease which every year kills in France about 20,000,000 francs' worth. Swine will also be preserved from the rouget disease which decimates them, and poultry from the cholera which makes such terrible havoc among them. Everything leads us to hope that rabies will also soon be conquered." When Paul Bert was congratulated on his report, he said, "Admiration is such a good, wholesome thing !!"

The Bill was voted by the Chamber, and a fortnight later by the Senate, unanimously. Pasteur heard the first news through the newspapers, for he had just gone to the Jura. On July 14, he left Arbois for Dôle, where he had promised to be present at a double ceremony.

On that national holiday, a statue of Peace was to be inaugurated, and a memorial plate placed on the house where Pasteur was born; truly a harmonious association of ideas. The prefect of the Jura evidently felt it when, while unveiling the statue in the presence of Pasteur, he said: "This is Peace, who has inspired Genius and the great services it has rendered." The official procession, followed by popular acclamation, went on to the narrow Rue des

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Tanneurs. When Pasteur, who had not seen his native place since his childhood, found himself before that tannery, in the low humble rooms of which his father and mother had lived, he felt himself the prey to a strong emotion.

The mayor quoted these words from the resolutions of the Municipal Council: "M. Pasteur is a benefactor of Humanity, one of the great men of France; he will remain for all Dôlois and in particular those who, like him, have risen from the ranks of the people, an object of respect as well as an example to follow; we consider that it is our duty to perpetuate his name in our town."

The Director of Fine Arts, M. Kaempfen, representing the Government at the ceremony, pronounced these simple words: "In the name of the Government of the Republic, I salute the inscription which commemorates the fact that in this little house, in this little street, was born, on December 27, 1822, he who was to become one of the greatest scientists of this century so great in science, and who has, by his admirable labours, increased the glory of France and deserved well of the whole of humanity."

The feelings in Pasteur's heart burst forth in these terms: "Gentlemen, I am profoundly moved by the honour done to me by the town of Dôle; but allow me, while expressing my gratitude, to protest against this excess of praise. By according to me an homage rendered usually but to the illustrious dead, you anticipate too much the judgment of posterity. Will it ratify your decision? and should not you, Mr. Mayor, have prudently warned the Municipal Council against such a hasty resolution?"

"But after protesting, gentlemen, against the brilliant testimony of an admiration which is more than I deserve, let me tell you that I am touched, moved to the bottom of my soul. Your sympathy has joined on that memorial plate the two great things which have been the passion and

the delight of my life : the love of Science and the cult of the home.

"Oh ! my father, my mother, dear departed ones, who lived so humbly in this little house, it is to you that I owe everything. Thy enthusiasm, my brave-hearted mother, thou hast instilled it into me. If I have always associated the greatness of Science with the greatness of France, it is because I was impregnated with the feelings that thou hadst inspired. And thou, dearest father, whose life was as hard as thy hard trade, thou hast shown to me what patience and protracted effort can accomplish. It is to thee that I owe perseverance in daily work. Not only hadst thou the qualities which go to make a useful life, but also admiration for great men and great things. To look upwards, learn to the utmost, to seek to rise ever higher, such was thy teaching. I can see thee now, after a hard day's work, reading in the evening some story of the battles in the glorious epoch of which thou wast a witness. Whilst teaching me to read, thy care was that I should learn the greatness of France.

"Be ye blessed, my dear parents, for what ye have been, and may the homage done to-day to your little house be yours !

"I thank you, gentlemen, for the opportunity of saying aloud what I have thought for sixty years. I thank you for this fête and for your welcome, and I thank the town of Dôle, which loses sight of none of her children, and which has kept such a remembrance of me."

"Nothing is more exquisite," wrote Bouley to Pasteur, "than those feelings of a noble heart, giving credit to the parents' influence for all the glory with which their son has covered their name. All your friends recognized you, and you appeared under quite a new light to those who may have misjudged your heart by knowing of you only

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the somewhat bitter words of some of your Academy speeches, when the love of truth has sometimes made you forgetful of gentleness."

It might have seemed that after so much homage, especially when offered in such a delicate way as on this last occasion, Pasteur had indeed reached a pinnacle of fame. His ambition however was not satisfied. Was it then boundless, in spite of the modesty which drew all hearts towards him? What more did he wish? Two great things: to complete his studies on hydrophobia and to establish the position of his collaborators—whose name he ever associated with his work—as his acknowledged successors.

A few cases of cholera had occurred at Damietta in the month of June. The English declared that it was but endemic cholera, and opposed the quarantines. They had with them the majority of the Alexandria Sanitary Council, and could easily prevent sanitary measures from being taken. If the English, voluntarily closing their eyes to the dangers of the epidemic, had wished to furnish a new proof of the importation of cholera, they could not have succeeded better. The cholera spread, and by July 14 it had reached Cairo. Between the 14th and the 22nd there were five hundred deaths per day. -

Alexandria was threatened. Pasteur, before leaving Paris for Arbois, submitted to the Consulting Committee of Public Hygiene the idea of a French Scientific Mission to Alexandria. "Since the last epidemic in 1865," he said, "science has made great progress on the subject of transmissible diseases. Every one of those diseases which has been subjected to a thorough study has been found by biologists to be produced by a microscopic being developing within the body of man or of animals, and causing therein

ravages which are generally mortal. All the symptoms of the disease, all the causes of death depend directly upon the physiological properties of the microbe. . . . What is wanted at this moment to satisfy the preoccupations of science is to inquire into the primary cause of the scourge. Now the present state of knowledge demands that attention should be drawn to the possible existence within the blood, or within some organ, of a micro-organism whose nature and properties would account in all probability for all the peculiarities of cholera, both as to the morbid symptoms and the mode of its propagation. The proved existence of such a microbe would soon take precedence over the whole question of the measures to be taken to arrest the evil in its course, and might perhaps suggest new methods of treatment."

Not only did the Committee of Hygiene approve of Pasteur's project, but they asked him to choose some young men whose knowledge would be equalled by their devotion. Pasteur only had to look around him. When, on his return to the laboratory, he mentioned what had taken place at the Committee of Hygiene, M. Roux immediately offered to start. A professor at the Faculty of Medicine who had some hospital practice, M. Straus, and a professor at the Alfort Veterinary School, M. Nocard, both of whom had been authorised to work in the laboratory, asked permission to accompany M. Roux. Thuillier had the same desire, but asked for twenty-four hours to think over it.

The thought of his father and mother, who had made a great many sacrifices for his education, and whose only joy was to receive him at Amiens, where they lived, during his short holidays, made him hesitate. But the thought of duty overcame his regrets ; he put his papers and notes in order and went to see his dear ones again. He told his father of his intention, but his mother did not know of it. At the

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time when the papers spoke of a French commission to study cholera, his elder sister, who loved him with an almost motherly tenderness, said to him suddenly, "You are not going to Egypt, Louis? swear that you are not!" "I am not going to swear anything," he answered, with absolute calm; adding that he might some time go to Russia to proceed to some vaccination of anthrax, as he had done at Buda-Pesth in 1881. When he left Amiens, nothing in his farewells revealed his deep emotion; it was only from Marseilles that he wrote the truth.

Administrative difficulties retarded the departure of the Commission, which only reached Egypt on August 15. Dr. Koch had also come to study cholera. The head physician of the European hospital, Dr. Arduouin, placed his wards at the entire disposal of the French savants. In a certain number of cases, it was possible to proceed to post-mortem examinations immediately after death, before putrefaction had begun. It was a great thing from the point of view of the search after a pathogenic micro-organism as well as from the anatomo-pathological point of view.

The contents of the intestines and the characteristic stools of the cholera patients offered a great variety of micro-organisms. But which was really the cause of cholera? The most varied modes of culture were attempted in vain. The same negative results followed inoculations into divers animal species, cats, dogs, swine, monkeys, pigeons, rabbits, guinea-pigs, etc., made with the blood of choleric or with the contents of their bowels. Experiments were made with twenty-four corpses. The epidemic ceased unexpectedly. Not to waste time, while waiting for a reappearance of the disease, the French Commission took up some researches on cattle plague. Suddenly a telegram

from M. Roux informed Pasteur that Thuillier had succumbed to an attack of cholera.

"I have just heard the news of a great misfortune," wrote Pasteur to J. B. Dumas on September 19; "M. Thuillier died yesterday at Alexandria of cholera. I have telegraphed to the Mayor of Amiens asking him to break the news to the family."

"Science loses in Thuillier a courageous representative with a great future before him. I lose a much-loved and devoted pupil ; my laboratory one of its principal supports.

"I can only console myself for this death by thinking of our beloved country and all he has done for it."

Thuillier was only twenty-six. How had this happened ? Had he neglected any of the precautions which Pasteur had written down before the departure of the Commission, and which were so minute as to be thought exaggerated ?

Pasteur remained silent all day, absolutely overcome. The head of the laboratory, M. Chamberland, divining his master's grief, came to Arbois. They exchanged their sorrowful thoughts, and Pasteur fell back into his sad broodings.

A few days later, a letter from M. Roux related the sad story : " *Alexandria, September 21.* Sir and dear master— Having just heard that an Italian ship is going to start, I am writing a few lines without waiting for the French mail. The telegraph has told you of the terrible misfortune which has befallen us."

M. Roux then proceeded to relate in detail the symptoms presented by the unfortunate young man, who, after going to bed at ten o'clock, apparently in perfect health, had suddenly been taken ill about three o'clock in the morning of Saturday, September 15. At eight o'clock, all the horrible symptoms of the most violent form of cholera were apparent, and his friends gave him up for lost. They continued their

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desperate endeavours however, assisted by the whole staff of French and Italian doctors.

"By dint of all our strength, all our energy, we protracted the struggle until seven o'clock on Wednesday morning, the 19th. The asphyxia, which had then lasted twenty-four hours, was stronger than our efforts.

"Your own feelings will help you to imagine our grief.

"The French colony and the medical staff are thunderstruck. Splendid funeral honours have been rendered to our poor Thuillier.

"He was buried at four o'clock on Wednesday afternoon, with the finest and most imposing manifestation Alexandria had seen for a long time.

"One very precious and affecting homage was rendered by the German Commission with a noble simplicity which touched us all very much.

"M. Koch and his collaborators arrived when the news spread in the town. They gave utterance to beautiful and touching words to the memory of our dead friend. When the funeral took place, those gentlemen brought two wreaths which they themselves nailed on the coffin. 'They are simple,' said M. Koch, 'but they are of laurel, such as are given to the brave.'

"M. Koch held one corner of the pall. We embalmed our comrade's body ; he lies in a sealed zinc coffin. All formalities have been complied with, so that his remains may be brought back to France when the necessary time has expired. In Egypt the period of delay is a whole year.

"The French colony desires to erect a monument to the memory of Louis Thuillier.

"Dear master, how much more I should like to tell you ! The recital of the sad event which happened so quickly would take pages. This blow is altogether incomprehensible. It was more than a fortnight since we had seen a

single case of cholera ; we were beginning to study cattle-plague.

"Of us all, Thuillier was the one who took most precautions ; he was irreproachably careful.

"We are writing by this post a few lines to his family, in the names of all of us.

"Such are the blows cholera can strike at the end of an epidemic ! Want of time forces me to close this letter. Pray believe in our respectful affection."

The whole of the French colony, who received great marks of sympathy from the Italians and other foreigners, wished to perpetuate the memory of Thuillier. Pasteur wrote, on October 16, to a French physician at Alexandria, who had informed him of this project :

"I am touched with the generous resolution of the French colony at Alexandria to erect a monument to the memory of Louis Thuillier. That valiant and beloved young man was deserving of every honour. I know, perhaps better than any one, the loss inflicted on science by his cruel death. I cannot console myself, and I am already dreading the sight of the dear fellow's empty place in my laboratory."

On his return to Paris, Pasteur read a paper to the Academy of Sciences, in his own name and in that of Thuillier, on the now well-ascertained mode of vaccination for swine-fever. He began by recalling Thuillier's worth :

"Thuillier entered my laboratory after taking the first rank at the Physical Science Agrégation competition at the Ecole Normale. His was a deeply meditative, silent nature ; his whole person breathed a virile energy which struck all those who knew him. An indefatigable worker, he was ever ready for self-sacrifice."

A few days before, M. Straus had given to the Biology

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Society a summary statement of the studies of the Cholera Commission, concluding thus: "The documents collected during those two months are far from solving the etiological problem of cholera, but will perhaps not be useless for the orientation of future research."

The cholera bacillus was put in evidence, later on, by Dr. Koch, who had already suspected it during his researches in Egypt.

Glory, which had been seen in the battlefield at the beginning of the nineteenth century, now seemed to elect to dwell in the laboratory, that "temple of the future" as Pasteur called it. From every part of the world, letters reached Pasteur, appeals, requests for consultations. Many took him for a physician. "He does not cure individuals," answered Edmund About one day to a foreigner who was under that misapprehension; "he only tries to cure humanity." Some sceptical minds were predicting failure to his studies on hydrophobia. This problem was complicated by the fact that Pasteur was trying in vain to discover and isolate the specific microbe.

He was endeavouring to evade that difficulty; the idea pursued him that human medicine might avail itself of "the long period of incubation of hydrophobia, by attempting to establish, during that interval before the appearance of the first rabic symptoms, a refractory condition in the subjects bitten."

At the beginning of the year 1884, J. B. Dumas enjoyed following from a distance Pasteur's readings at the Académie des Sciences. His failing health and advancing age (he was more than eighty years old) had forced him to spend the winter in the South of France. On January 26, 1884 he wrote to Pasteur for the last time, à propos of a book¹

¹ *La Vie d'un Savant*, by the author of the present work. [Trans.]

which was a short summary of Pasteur's discoveries and their concatenation :

" Dear colleague and friend,—I have read with a great and sincere emotion the picture of your scientific life drawn by a faithful and loving hand.

" Myself a witness and a sincere admirer of your happy efforts, your fruitful genius and your imperturbable method, I consider it a great service rendered to Science, that the accurate and complete whole should be put before the eyes of young people.

" It will make a wholesome impression on the public in general; to young scientists, it will be an initiation, and to those who, like me, have passed the age of labour it will bring happy memories of youthful enthusiasm.

" May Providence long spare you to France, and maintain in you that admirable equilibrium between the mind that observes, the genius that conceives, and the hand that executes with a perfection unknown until now."

This was a last proof of Dumas' affection for Pasteur. Although his life was now fast drawing to its close, his mental faculties were in no wise impaired, for we find him three weeks later, on February 20, using his influence as Permanent Secretary of the Academy to obtain the Lacaze prize for M. Cailletet, the inventor of the well-known apparatus for the liquefaction of gases.

J. B. Dumas died on April 11, 1884. Pasteur was then about to start for Edinburgh on the occasion of the tercentenary of the celebrated Scotch University. The "Institut de France," invited to take part in these celebrations, had selected representatives from each of the five Academies : the Académie Française was sending M. Caro ; the Academy of Science, Pasteur and de Lesseps ; the Academy of Moral Sciences, M. Gréard ; the Academy of Inscriptions and Letters, M. Perrot ; and the Academy of

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Fine Arts, M. Eugène Guillaume. The Collège de France sent M. Guillaume Guizot, and the Academy of Medicine Dr. Henry Gueneau de Mussy.

Pasteur much wished to relinquish this official journey ; the idea that he would not be able to follow to the grave the incomparable teacher of his youth, the counsellor and confidant of his life, was infinitely painful to him.

He was however reconciled to it by one of his colleagues, M. Mézières, who was going to Edinburgh on behalf of the Minister of Public Instruction, and who pointed out to him that the best way of honouring Dumas' memory lay in remembering Dumas' chief object in life—the interests of France. Pasteur went, hoping that he would have an opportunity of speaking of Dumas to the Edinburgh students.

In London, the French delegates had the pleasant surprise of finding that a private saloon had been reserved to take Pasteur and his friends to Edinburgh. This hospitality was offered to Pasteur by one of his numerous admirers, Mr. Younger, an Edinburgh brewer, as a token of gratitude for his discoveries in the manufacture of beer. He and his wife and children welcomed Pasteur with the warmest cordiality, when the train reached Edinburgh ; the principal inhabitants of the great Scotch city vied with each other in entertaining the French delegates, who were delighted with their reception.

The next morning, they, and the various representatives from all parts of the world, assembled in the Cathedral of St. Giles, where, with the exalted feeling which, in the Scotch people, mingles religious with political life, the Town Council had decided that a service should inaugurate the rejoicings. The Rev. Robert Flint, mounting that pulpit from which the impetuous John Knox, Calvin's friend and disciple, had breathed forth his violent fanaticism, preached to the immense assembly with a full consciousness of the

importance of his discourse. He spoke of the relations between Science and Faith, of the absolute liberty of science in the realm of facts, of the thought of God considered as a stimulant to research, progress being but a Divine impulse.

In the afternoon, the students imparted life and merriment into the proceedings; they had organized a dramatic performance, the members of the orchestra, even, being undergraduates.

The French delegates took great interest in the system of this University. Accustomed as they were to look upon the State as sole master and dispenser, they now saw an independent institution, owing its fortune to voluntary contributions, revealing in every point the power of private enterprise. Unlike what takes place in France, where administrative unity makes itself felt in the smallest village, the British Government effaces itself, and merely endeavours to inspire faith in political unity. Absolutely her own mistress, the University of Edinburgh is free to confer high honorary degrees on her distinguished visitors. However, these honorary diplomas are but of two kinds, viz.: Doctor of Divinity (D.D.) and Doctor of Laws (LL.D.). In 1884, seventeen degrees of D.D. and 122 degrees of LL.D. were reserved for the various delegates. "The only laws I know," smilingly said the learned Helmholtz, "are the laws of Physics."

The solemn proclamation of the University degrees took place on Thursday, April 17. The streets and monuments of the beautiful city were decorated with flags, and an air of rejoicing pervaded the whole atmosphere.

The ceremony began by a special prayer, alluding to the past, looking forward to the future, and asking for God's blessing on the delegates and their countries. The large assembly filled the immense hall where the Synod of the Presbyterian Church holds its meetings. The Chancellor

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and the Rector of the University were seated on a platform with a large number of professors ; those who were about to receive honorary degrees occupied seats in the centre of the hall ; about three thousand students found seats in various parts of the hall.

The Chancellor of the University of Edinburgh had arranged that the new graduates should be called in alphabetical order. As each of them heard his name, he rose and mounted the platform. The students took great pleasure in heartily cheering those *savants* who had had most influence on their studies. When Pasteur's name was pronounced, a great silence ensued ; every one was trying to obtain a sight of him as he walked towards the platform. His appearance was the signal for a perfect outburst of applause ; five thousand men rose and cheered him. It was indeed a splendid ovation.

In the evening, a banquet was set out in the hall, which was hung with the blue and white colours of the University ; there were a thousand guests, seated round twenty-eight tables, one of which, the high table, was reserved for the speakers who were to propose the toasts, which were to last four hours. Pasteur was seated next to Virchow ; they talked together of the question of rabies, and Virchow owned that, when he saw Pasteur in 1881 about to tackle this question, he much doubted the possibility of a solution. This friendly chat between two such men proves the desirability of such gatherings ; intercourse between the greatest scientists can but lead to general peace and fraternity between nations. After having read a telegram from the Queen, congratulating the University and welcoming the guests, a toast was drunk to the Queen and to the Royal Family, and a few words spoken by the representative of the Emperor of Brazil. Pasteur then rose to speak :

" My Lord Chancellor, Gentlemen, the city of Edinburgh is now offering a sight of which she may be proud. All the great scientific institutions, meeting here, appear as an immense Congress of hopes and congratulations. The honour and glory of this international rendezvous deservedly belong to you, for it is centuries since Scotland united her destinies with those of the human mind. She was one of the first among the nations to understand that intellect leads the world. And the world of intellect, gladly answering your call, lays a well-merited homage at your feet. When, yesterday, the eminent Professor Robert Flint, addressing the Edinburgh University from the pulpit of St. Giles, exclaimed, 'Remember the past and look to the future,' all the delegates, seated like judges at a great tribunal, evoked a vision of past centuries and joined in a unanimous wish for a yet more glorious future.

" Amongst the illustrious delegates of all nations who bring you an assurance of cordial good wishes, France has sent to represent her those of her institutions which are most representative of the French spirit and the best part of French glory. France is ready to applaud whenever a source of light appears in the world; and when death strikes down a man of genius, France is ready to weep as for one of her own children. This noble spirit of solidarity was brought home to me when I heard some of you speak feelingly of the death of the illustrious chemist, J. B. Dumas, a celebrated member of all your Academies, and only a few years ago an eloquent panegyrist of your great Faraday. It was a bitter grief to me that I had to leave Paris before his funeral ceremony; but the hope of rendering here a last and solemn homage to that revered master helped me to conquer my affliction. Moreover, gentlemen, men may pass, but their works remain; we all are but passing guests of these great homes of intellect, which, like

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all the Universities who have come to greet you in this solemn day, are assured of immortality."

Pasteur, having thus rendered homage to J. B. Dumas, and having glorified his country by his presence, his speech and the great honours conferred on him, would have returned home at once; but the undergraduates begged to be allowed to entertain, the next day, some of those men whom they looked upon as examples and whom they might never see again.

Pasteur thanked the students for this invitation, which filled him with pride and pleasure, for he had always loved young people, he said, and continued, in his deep, stirring voice:

"Ever since I can remember my life as a man, I do not think I have ever spoken for the first time with a student without saying to him, 'Work perseveringly; work can be made into a pleasure, and alone is profitable to man, to his city, to his country.' It is even more natural that I should thus speak to you. The common soul, (if I may so speak), of an assembly of young men is wholly formed of the most generous feelings, being yet illumined with the divine spark which is in every man as he enters this world. You have just given a proof of this assurance, and I have felt moved to the heart in hearing you applaud, as you have just been doing, such men as de Lesseps, Helmholtz and Virchow. Your language has borrowed from ours the beautiful word *enthusiasm*, bequeathed to us by the Greeks: *εν θεός*, an inward God. It was almost with a divine feeling that you just now cheered those great men.

"One of those of our writers who have best made known to France and to Europe the philosophy of Robert Reid and Dugald Stewart said, addressing young men in the preface of one of his works :—

"Whatever career you may embrace, look up to an exalted goal; worship great men and great things."

"Great things! You have indeed seen them. Will not this centenary remain one of Scotland's glorious memories? As to great men, in no country is their memory better honoured than in yours. But, if work should be the very life of your life, if the cult for great men and great things should be associated with your every thought, that is still not enough. Try to bring into everything you undertake the spirit of scientific method, founded on the immortal works of Galileo, Descartes and Newton.

"You especially, medical students of this celebrated University of Edinburgh—who, trained as you are by eminent masters, may aspire to the highest scientific ambition—be you inspired by the experimental method. To its principles, Scotland owes such men as Brewster, Thomson and Lister."

The speaker who had to respond on behalf of the students to the foreign delegates expressed himself thus, directly addressing Pasteur:

"Monsieur Pasteur, you have snatched from nature secrets too carefully, almost maliciously hidden. We greet in you a benefactor of humanity, all the more so because we know that you admit the existence of spiritual secrets, revealed to us by what you have just called the work of God in us.

"Representatives of France, we beg you to tell your great country that we are following with admiration the great reforms now being introduced into every branch of your education, reforms which we look upon as tokens of a beneficent rivalry and of a more and more cordial intercourse—for misunderstandings result from ignorance, a darkness lightened by the work of scientists."

The next morning, at ten o'clock, crowds gathered on the

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station platform with waving handkerchiefs. People were showing each other a great Edinburgh daily paper, in which Pasteur's speech to the undergraduates was reproduced, and which also contained the following announcement in large print:

"In memory of M. Pasteur's visit to Edinburgh, Mr. Younger offers to the Edinburgh University a donation of £500."

Livingstone's daughter, Mrs. Bruce, on whom Pasteur had called the preceding day, came to the station a few moments before the departure of the train, bringing him a book entitled *The Life of Livingstone*.

The saloon carriage awaited Pasteur and his friends. They departed, delighted with the hospitality they had received, and much struck with the prominent place given to science and the welcome accorded to Pasteur. "This is indeed glory," said one of them. "Believe me," said Pasteur, "I only look upon it as a reason for continuing to go forward as long as my strength does not fail me."

CHAPTER V

1884-1885

AMIDST the various researches undertaken in his laboratory, one study was placed by Pasteur above every other, one mystery constantly haunted his mind—that of hydrophobia. When he was received at the Académie Française, Renan, hoping to prove himself a prophet for once, said to him: "Humanity will owe to you deliverance from a horrible disease and also from a sad anomaly: I mean the distrust which we cannot help mingling with the caresses of the animal in whom we see most of nature's smiling benevolence."

The two first mad dogs brought into the laboratory were given to Pasteur, in 1880, by M. Bourrel, an old army veterinary surgeon who had long been trying to find a remedy for hydrophobia. He had invented a preventive measure which consisted in filing down the teeth of dogs, so that they should not bite into the skin; in 1874, he had written that vivisection threw no light on that disease, the laws of which were "impenetrable to science until now." It now occurred to him that, perhaps, the investigators in the laboratory of the Ecole Normale might be more successful than he had been in his kennels in the Rue Fontaine-au-Roi.

One of the two dogs he sent was suffering from what is called *dumb madness*: his jaw hung, half opened and paralyzed, his tongue was covered with foam, and his eyes full of wistful anguish; the other made ferocious darts at

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anything held out to him, with a rabid fury in his bloodshot eyes, and, in the hallucinations of his delirium, gave vent to haunting, despairing howls.

Much confusion prevailed at that time regarding this disease, its seat, its causes, and its remedy. Three things seemed positive: firstly, that the rabic virus was contained in the saliva of the mad animals; secondly, that it was communicated through bites; and thirdly, that the period of incubation might vary from a few days to several months. Clinical observation was reduced to complete impotence; perhaps experiments might throw some light on the subject.

Bouley had affirmed in April, 1870, that the germ of the evil was localized in the saliva, and a new fact had seemed to support this theory. On December 10, 1880, Pasteur was advised by Professor Lannelongue that a five-year-old child, bitten on the face a month before, had just been admitted into the Hôpital Trousseau. The unfortunate little patient presented all the characteristics of hydrophobia: spasms, restlessness, shudders at the least breath of air, an ardent thirst, accompanied with an absolute impossibility of swallowing, convulsive movements, fits of furious rage—not one symptom was absent. The child died after twenty-four hours of horrible suffering—suffocated by the mucus which filled the mouth. Pasteur gathered some of that mucus four hours after the child's death, and mixed it with water; he then inoculated this into some rabbits, which died in less than thirty-six hours, and whose saliva, injected into other rabbits, provoked an almost equally rapid death. Dr. Maurice Raynaud, who had already declared that hydrophobia could be transmitted to rabbits through the human saliva, and who had also caused the death of some rabbits with the saliva of that same child, thought himself justified in saying that those rabbits had died of hydrophobia.

Pasteur was slower in drawing conclusions. He had examined with a microscope the blood of those rabbits which had died in the laboratory, and had found in it a micro-organism; he had cultivated this organism in veal broth, inoculated it into rabbits and dogs, and, its virulence having manifested itself in these animals, their blood had been found to contain that same microbe. "But," added Pasteur at the meeting of the Academy of Medicine (January 18, 1881), "I am absolutely ignorant of the connection there may be between this new disease and hydrophobia." It was indeed a singular thing that the deadly issue of this disease should occur so early, when the incubation period of hydrophobia is usually so long. Was there not some unknown microbe associated with the rabid saliva? This query was followed by experiments made with the saliva of children who had died of ordinary diseases, and even with that of healthy adults. Thuillier, following up and studying this saliva microbe and its special virulence with his usual patience, soon applied to it with success the method of attenuation by the oxygen in air. "What did we want with a new disease?" said a good many people, and yet it was making a step forward to clear up this preliminary confusion. Pasteur, in the course of a long and minute study of the saliva of mad dogs—in which it was so generally admitted that the virulent principle of rabies had its seat, that precautions against saliva were the only ones taken at post-mortem examinations—discovered many other mistakes. If a healthy dog's saliva contains many microbes, licked up by the dog in various kinds of dirt, what must be the condition of the mouth of a rabid dog, springing upon everything he meets, to tear it and bite it? The rabid virus is therefore associated with many other micro-organisms, ready to play their part and puzzle experimentalists; abscesses, morbid complications of all

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sorts, may intervene before the development of the rabic virus. Hydrophobia might evidently be developed by the inoculation of saliva, but it could not be confidently asserted that it would. Pasteur had made endless efforts to inoculate rabies to rabbits solely through the saliva of a mad dog ; as soon as a case of hydrophobia occurred in Bourrel's kennels, a telegram informed the laboratory, and a few rabbits were immediately taken round in a cab.

One day, Pasteur having wished to collect a little saliva from the jaws of a rabid dog, so as to obtain it directly, two of Bourrel's assistants undertook to drag a mad bulldog, foaming at the mouth, from its cage ; they seized it by means of a lasso, and stretched it on a table. These two men, thus associated with Pasteur in the same danger, with the same calm heroism, held the struggling, ferocious animal down with their powerful hands, whilst the scientist drew, by means of a glass tube held between his lips, a few drops of the deadly saliva.

But the same uncertainty followed the inoculation of the saliva ; the incubation was so slow that weeks and months often elapsed whilst the result of an experiment was being anxiously awaited. Evidently the saliva was not a sure agent for experiments, and if more knowledge was to be obtained, some other means had to be found of obtaining it.

Magendie and Renault had both tried experimenting with rabic blood, but with no results, and Paul Bert had been equally unsuccessful. Pasteur tried in his turn, but also in vain. "We must try other experiments," he said, with his usual indefatigable perseverance.

As the number of cases observed became larger, he felt a growing conviction that hydrophobia has its seat in the nervous system, and particularly in the medulla oblongata. "The propagation of the virus in a rabid dog's nervous

system can almost be observed in its every stage," writes M. Roux, Pasteur's daily associate in these researches, which he afterwards made the subject of his thesis. "The anguish and fury due to the excitation of the grey cortex of the brain are followed by an alteration of the voice and a difficulty in deglutition. The medulla oblongata and the nerves starting from it are attacked in their turn; finally, the spinal cord itself becomes invaded and paralysis closes the scene."

As long as the virus has not reached the nervous centres, it may sojourn for weeks or months in some point of the body; this explains the slowness of certain incubations, and the fortunate escapes after some bites from rabid dogs. The *a priori* supposition that the virus attacks the nervous centres went very far back; it had served as a basis to a theory enunciated by Dr. Duboué (of Pau), who had, however, not supported it by any experiments. On the contrary, when M. Galtier, a professor at the Lyons Veterinary School, had attempted experiments in that direction, he had to inform the Academy of Medicine, in January, 1881, that he had only ascertained the existence of virus in rabid dogs in the lingual glands and in the bucco-pharyngeal mucous membrane. "More than ten times, and always unsuccessfully, have I inoculated the product obtained by pressure of the cerebral substances of the cerebellum or of the medulla oblongata of rabid dogs."

Pasteur was about to prove that it was possible to succeed by operating in a special manner, according to a rigorous technique, unknown in other laboratories. When the post-mortem examination of a mad dog had revealed no characteristic lesion, the brain was uncovered, and the surface of the medulla oblongata scalded with a glass stick, so as to destroy any external dust or dirt. Then, with a long tube, previously put through a flame, a particle of the substance

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was drawn and deposited in a glass just taken from a stove heated up to 200° C., and mixed with a little water or sterilized broth by means of a glass agitator, also previously put through a flame. The syringe used for inoculation on the rabbit or dog (lying ready on the operating board) had been purified in boiling water.

Most of the animals who received this inoculation under the skin succumbed to hydrophobia ; that virulent matter was therefore more successful than the saliva, which was a great result obtained.

"The seat of the rabid virus," wrote Pasteur, "is therefore not in the saliva only : the brain contains it in a degree of virulence at least equal to that of the saliva of rabid animals." But, to Pasteur's eyes, this was but a preliminary step on the long road which stretched before him ; it was necessary that all the inoculated animals should contract hydrophobia, and the period of incubation had to be shortened.

It was then that it occurred to Pasteur to inoculate the rabid virus directly on the surface of a dog's brain. He thought that, by placing the virus from the beginning in its true medium, hydrophobia would more surely supervene and the incubation might be shorter. The experiment was attempted : a dog under chloroform was fixed to the operating board, and a small, round portion of the cranium removed by means of a trephine (a surgical instrument somewhat similar to a fret-saw) ; the tough fibrous membrane called the dura-mater, being thus exposed, was then injected with a small quantity of the prepared virus, which lay in readiness in a Pravaz syringe. The wound was washed with carbolic and the skin stitched together, the whole thing lasting but a few minutes. The dog, on returning to consciousness, seemed quite the same

as usual. But, after fourteen days, hydrophobia appeared : rabid fury, characteristic howls, the tearing up and devouring of his bed, delirious hallucination, and finally, paralysis and death.

A method was therefore found by which rabies was contracted surely and swiftly. Trephining were again performed on chloroformed animals—Pasteur had a great horror of useless sufferings, and always insisted on anaesthesia.—In every case, characteristic hydrophobia occurred after inoculation on the brain. The main lines of this complicated question were beginning to be traceable ; but other obstacles were in the way. Pasteur could not apply the method he had hitherto used, *i.e.* : to isolate, and then to cultivate in an artificial medium, the microbe of hydrophobia, for he failed in detecting this microbe. Yet its existence admitted of no doubt ; perhaps it was beyond the limits of human sight. “Since this unknown being is living,” thought Pasteur, “we must cultivate it ; failing an artificial medium, let us try the brain of living rabbits ; it would indeed be an experimental feat !”

As soon as a trephined and inoculated rabbit died paralysed, a little of his rabid medulla was inoculated to another ; each inoculation succeeded another, and the time of incubation became shorter and shorter, until, after a hundred uninterrupted inoculations, it came to be reduced to seven days. But the virus, having reached this degree, the virulence of which was found to be greater than that of the virus of dogs made rabid by an accidental bite, now became fixed ; Pasteur had mastered it. He could now predict the exact time when death should occur in each of the inoculated animals ; his predictions were verified with surprising accuracy.

Pasteur was not yet satisfied with the immense progress marked by infallible inoculation and the shortened incuba-

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tion ; he now wished to decrease the degrees of virulence —when the attenuation of the virus was once conquered, it might be hoped that dogs could be made refractory to rabies. Pasteur abstracted a fragment of the medulla from a rabbit which had just died of rabies after an inoculation of the fixed virus ; this fragment was suspended by a thread in a sterilized phial, the air in which was kept dry by some pieces of caustic potash lying at the bottom of the vessel and which was closed by a cotton-wool plug to prevent the entrance of atmospheric dusts. The temperature of the room where this dessication took place was maintained at 23°C . As the medulla gradually became dry, its virulence decreased, until, at the end of fourteen days, it had become absolutely extinguished. This now inactive medulla was crushed and mixed with pure water, and injected under the skin of some dogs. The next day they were inoculated with medulla which had been dessicating for thirteen days, and so on, using increased virulence until the medulla was used of a rabbit dead the same day. These dogs might now be bitten by rabid dogs given them as companions for a few minutes, or submitted to the intracranial inoculations of the deadly virus : they resisted both.

Having at last obtained this refractory condition, Pasteur was anxious that his results should be verified by a Commission. The Minister of Public Instruction acceded to this desire, and a Commission was constituted in May, 1884, composed of Messrs. Béclard, Dean of the Faculty of Medicine, Paul Bert, Bouley, Villemin, Vulpian, and Tisserand, Director of the Agriculture Office. The Commission immediately set to work ; a rabid dog having succumbed at Alfort on June 1, its carcase was brought to the laboratory of the Ecole Normale, and a fragment of the medulla oblongata was mixed with some sterilized broth. Two dogs, declared by Pasteur to be refractory to rabies,

were trephined, and a few drops of the liquid injected into their brains; two other dogs and two rabbits received inoculations at the same time, with the same liquid and in precisely the same manner.

Bouley was taking notes for a report to be presented to the Minister :

"M. Pasteur tells us that, considering the nature of the rabid virus used, the rabbits and the two new dogs will develop rabies within twelve or fifteen days, and that the two refractory dogs will not develop it at all, however long they may be detained under observation."

On May 29, Mme. Pasteur wrote to her children :

"The Commission on rabies met to-day and elected M. Bouley as chairman. Nothing is settled as to commencing experiments. Your father is absorbed in his thoughts, talks little, sleeps little, rises at dawn, and, in one word, continues the life I began with him this day thirty-five years ago."

On June 3, Bourrel sent word that he had a rabid dog in the kennels of the Rue Fontaine au Roi; a refractory dog and a new dog were immediately submitted to numerous bites; the latter was violently bitten on the head in several places. The rabid dog, still living the next day and still able to bite, was given two more dogs, one of which was refractory; this dog, and the refractory dog bitten on the 3rd, were allowed to receive the first bites, the commission having thought that perhaps the saliva might then be more abundant and more dangerous.

On June 6, the rabid dog having died, the Commission proceeded to inoculate the medulla of the animal into six more dogs, by means of trephining. Three of those dogs were refractory, the three others were fresh from the kennels; there were also two rabbits.

On the 10th, Bourrel telegraphed the arrival of another rabid dog, and the same operations were gone through.

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"This rabid, furious dog," wrote Pasteur to his son-in-law, "had spent the night lying on his master's bed; his appearance had been suspicious for a day or two. On the morning of the 10th, his voice became rabietic, and his master, who had heard the bark of a rabid dog twenty years ago, was seized with terror, and brought the dog to M. Bourrel, who found that he was indeed in the biting stage of rabies. Fortunately a lingering fidelity had prevented him from attacking his master

"This morning the rabic condition is beginning to appear on one of the new dogs trephined on June 1, at the same time as two refractory dogs. Let us hope that the other new dog will also develop it and that the two refractory ones will resist."

At the same time that the Commission examined this dog which developed rabies within the exact time indicated by Pasteur, the two rabbits on whom inoculation had been performed at the same time were found to present the first symptoms of rabic paralysis. "This paralysis," noted Bouley, is revealed by great weakness of the limbs, particularly of the hind quarters; the least shock knocks them over and they experience great difficulty in getting up again." The second new dog on whom inoculation had been performed on June 1 was now also rabid; the refractory dogs were in perfect health.

During the whole of June, Pasteur found time to keep his daughter and son-in-law informed of the progress of events. "Keep my letters," he wrote, "they are almost like copies of the notes taken on the experiments."

Towards the end of the month, dozens of dogs were submitted to control-experiments which were continued until August. The dogs which Pasteur declared to be refractory underwent all the various tests made with rabic virus; bites, injections into the veins, trephining, every-

thing was tried before Pasteur would decide to call them vaccinated. On June 17, Bourrel sent word that the new dog bitten on June 3 was becoming rabid; the members of the Commission went to the Rue Fontaine au Roi. The period of incubation had only lasted fourteen days, a fact attributed by Bouley to the bites having been chiefly about the head. The dog was destroying his kennel and biting his chain ferociously. More new dogs developed rabies the following days. Nineteen new dogs had been experimented upon: three died out of six bitten by a rabid dog, six out of eight after intravenous inoculation, and five out of five after subdural inoculation. Bouley thought that a few more cases might occur, the period of incubation after bites being so extremely irregular.

Bouley's report was sent to the Minister of Public Instruction at the beginning of August. "We submit to you to-day," he wrote, "this report on the first series of experiments that we have just witnessed, in order that M. Pasteur may refer to it in the paper which he proposes to read at the Copenhagen International Scientific Congress on these magnificent results, which devolve so much credit on French Science and which give it a fresh claim to the world's gratitude."

The Commission wished that a large kennel yard might be built, in order that the duration of immunity in protected dogs might be timed, and that other great problem solved, viz., whether it would be possible, through the inoculation of attenuated virus, to defy the virus from bites.

By the Minister's request, the Commission investigated the Meudon woods in search of a favourable site; an excellent place was found in the lower part of the Park, away from dwelling houses, easy to enclose and presumably in no one's way. But, when the inhabitants of Meudon heard of this project, they protested vehemently, evidently

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terrified at the thought of rabid dogs, however securely bound, in their peaceful neighbourhood.

Another piece of ground was then suggested to Pasteur, near St. Cloud, in the Park of Villeneuve l'Etang. Originally a State domain, this property had been put up for sale, but had found no buyer, not being suitable for parcelling out in small lots; the Bill was withdrawn which allowed of its sale and the greater part of the domain was devoted by the Ministry to Pasteur's and his assistants' experiments on the prophylaxis of contagious diseases.

Pasteur, his mind full of ideas, started for the International Medical Congress, which was now to take place at Copenhagen. Sixteen hundred members arranged to attend, and nearly all of them found on arriving that they were to be entertained in the houses of private individuals. The Danes carry hospitality to the most generous excess; several of them had been learning French for the last three years, the better to entertain the French delegates. Pasteur's son, then secretary of the French Legation at Copenhagen, had often spoken to his father with appreciative admiration of those Northerners, who hide deep enthusiasm under apparent calmness, almost coldness.

The opening meeting took place on August 10 in the large hall of the Palace of Industry; the King and Queen of Denmark and the King and Queen of Greece were present at that impressive gathering. The President, Professor Panum, welcomed the foreign members in the name of his country; he proclaimed the neutrality of Science, adding that the three official languages to be used during the Congress would be French, English, and German. His own speech was entirely in French, "the language which least divides us," he said, "and which we are accustomed to look upon as the most courteous in the world."

The former president of the London Congress, Sir James

Paget, emphasized the scientific consequences of those triennial meetings, showing that, thanks to them, nations may calculate the march of progress.

Virchow, in the name of Germany, developed the same idea.

Pasteur, representing France, showed again as he had done at Milan in 1878, in London in 1881, at Geneva in 1882, and quite recently in Edinburgh, how much the scientist and the patriot were one in him.

"In the name of France," said he, "I thank M. le President for his words of welcome . . . By our presence in this Congress, we affirm the neutrality of Science . . . Science is of no country. . . . But if Science has no country, the scientist must keep in mind all that may work towards the glory of his country. In every great scientist will be found a great patriot. The thought of adding to the greatness of his country sustains him in his long efforts, and throws him into the difficult but glorious scientific enterprises which bring about real and durable conquests. Humanity then profits by those labours coming from various directions. . . ."

At the end of the meeting Pasteur was presented to the King. The Queen of Denmark and the Queen of Greece, regardless of etiquette, walked towards him, "a signal proof," wrote a French contemporary, "of the esteem in which our illustrious countryman is held at the Danish Court."

Five general meetings were to give some of the scientists an opportunity of expounding their views on subjects of universal interest. Pasteur was asked to read the first paper; his audience consisted, besides the members of the Congress, of many other men interested in scientific things, who had come to hear him describe the steps by which he had made such secure progress in the arduous question of hydrophobia. He began by a declaration of war against

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the prejudice by which so many people believe that rabies can occur spontaneously. Whatever the pathological, physiological, or other conditions may be under which a dog or another animal is placed, rabies never appears if the animal has not been bitten or licked by another rabid animal; this is so truly the case that hydrophobia is unknown in certain countries. In order to preserve a whole land from the disease, it is sufficient that a law should, as in Australia, compel every imported dog to be in quarantine for several months; he would then, if bitten by a mad dog before his departure, have ample time to die before infecting other animals. Norway and Lapland are equally free from rabies, a few good prophylactic measures being sufficient to avert the scourge.

It will be objected that there must have been a first rabid dog originally. "That," said Pasteur, "is a problem which cannot be solved in the present state of knowledge, for it partakes of the great and unknown mystery of the origin of life."

The audience followed with an impassioned curiosity the history of the stages followed by Pasteur on the road to his great discovery: the preliminary experiments, the demonstration of the fact that the rabic virus invades the nervous centres, the culture of the virus within living animals, the attenuation of the rabic virus when passed from dogs to monkeys, and, simultaneously with this graduated attenuation, a converse process by successive passages from rabbit to rabbit, the possibility of obtaining in this way all the degrees of virulence, and finally the acquired certainty of having obtained a preventive vaccine against canine hydrophobia.

"Enthusiastic applause," wrote the reporter of the *Journal des Débats*, "greeted the conclusions of the indefatigable worker."

In the course of one of the excursions arranged for the members of the Congress, Pasteur had the pleasure of seeing his methods applied on a large scale, not as in Italy to the progress of sericulture, but to that of the manufacture of beer. J. C. Jacobsen, a Danish citizen, whose name was celebrated in the whole of Europe by his munificent donations to science, had founded in 1847 the Carlsberg Brewery, now one of the most important in the world ; at least 200,000 hectolitres were now produced every year by the Carlsberg Brewery and the Ny Carlsberg branch of it, which was under the direction of Jacobsen's son.

In 1879, Jacobsen, who was unknown to Pasteur, wrote to him, "I should be very much obliged if you would allow me to order from M. Paul Dubois, one of the great artists who do France so much credit, a marble bust of yourself, which I desire to place in the Carlsberg laboratory in token of the services rendered to chemistry, physiology, and beer-manufacture, by your studies on fermentation, a foundation to all future progress in the brewer's trade." Paul Dubois' bust is a masterpiece : it is most characteristic of Pasteur—the deep thoughtful far-away look in his eyes, a somewhat stern expression on his powerful features.

Actuated, like his father, by a feeling of gratitude, the younger Jacobsen had placed a bronze reproduction of this bust in a niche in the wall of the brewery, at the entrance of the Pasteur Street, leading to Ny Carlsberg.

This visit to the brewery was an object lesson to the members of the Congress, who were magnificently entertained by Jacobsen and his son ; no better demonstration was ever made of the services which industry may receive from science. In the great laboratory, the physiologist Hansen had succeeded in finding differences in yeast ; he had just separated from each other three kinds of yeast, each producing beer with a different flavour.

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The French scientists were delighted with the practical sense and delicate feelings of the Danish people. Though they had gone through bitter trials in 1864, though France, England, and Russia had countenanced the unrighteous invasion, in the face of the old treaties which guaranteed to Denmark the possession of Schleswig, the diminished and impoverished nation had not given vent to barren recriminations or declamatory protests. Proudly and silently sorrowing, the Danes had preserved their respect for the past, faith in justice and the cult of their great men. It is a strange thing that Shakespeare should have chosen that land of good sense and well-balanced reason, for the surroundings of his mysterious hero, of all men the most haunted by the maddening enigma of destiny.

Elsinore is but a short distance from Copenhagen, and no member of the Congress, especially among the English section, could have made up his mind to leave Denmark without visiting Hamlet's home. .

A Transport Company organized the visit to Elsinore for a day when the Congress had arranged to have a complete holiday. Five steamers, gay with flags, were provided for the thousand medical men and their families, and accomplished the two hours' crossing to Elsinore on a lovely, clear day, with an absolutely calm sea. The scientific tourists landed at the foot of the old Kronborg Castle, ready for the lunch which was served out to them and which proved barely sufficient for their appetites; there was not quite enough bread for the Frenchmen, proverbially bread-eaters, and the water, running a little short, had to be supplemented with champagne.

Some of the visitors returned from a neighbouring wood, where they had been to see the stones of the supposed tomb of Hamlet, disappointed at having looked in vain for Ophelia's stream and for the willow tree which heard her

sing her last song, her hands full of flowers. Evidently this place was but an imaginary scenery given by Shakespeare to the drama which stands like a point of interrogation before the mystery of human life ; but his life-giving art has for ever made of Elsinore the place where Hamlet lived and suffered.

Pasteur, to whom the Danish character, in its strength and simplicity, proved singularly attractive, remained in Copenhagen for some time after the Congress was over. He had much pleasure in visiting the Thorwaldsen Museum. Copenhagen, after showering honours on the great artist during his lifetime, has continued to worship him after his death. Every statue, every plaster cast, is preserved in that Museum with extraordinary care. Thorwaldsen himself lies in the midst of his works—his simple stone grave, covered with graceful ivy, is in one of the courtyards of the Museum.

Pasteur went on to Arbois from Copenhagen. The laboratory he had built there not being large enough to take in rabid dogs, he dictated from his study the experiments to be carried out in Paris ; his carefully kept notebooks enabled him to know exactly how things were going on. His nephew, Adrien Loir, now a curator in the laboratory of Rue d'Ulm had gladly given up his holidays and remained in Paris with the faithful Eugène Viala. This excellent assistant had come to Paris from Alais in 1871, at the request of Pasteur, who knew his family. Viala was then only twelve years old and could barely read and write. Pasteur sent him to an evening school and himself helped him with his studies ; the boy was very intelligent and willing to learn. He became most useful to Pasteur, who, in 1885, was glad to let him undertake a great deal of the laboratory work, under the guidance of

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M. Roux, he was ultimately entrusted with all the trephining operations on dogs, rabbits, and guinea-pigs.

The letters written to him by Pasteur in 1884 show the exact point reached at that moment by the investigations on hydrophobia. Many people already thought those studies advanced enough to allow the method of treatment to be applied to man.

Pasteur wrote to Viala on September 19, "Tell M. Adrien (Loir) to send the following telegram: 'Surgeon Symonds, Oxford, England. Operation on man still impossible. No possibility at present of sending attenuated virus.' See MM. Bourrel and Béraud, procure a dog which has died of street-rabies, and use its medulla to inoculate a new monkey, two guinea-pigs and two rabbits. . . . I am afraid Nocard's dog cannot have been rabid; even if you were sure that he was, you had better try those tests again."

"Since M. Bourrel says he has several mad dogs at present, you might take two couple of new dogs to his kennels; when he has a good biting dog, he can have a pair of our dogs bitten, after which you will treat one of them so as to make him refractory (carefully taking note of the time elapsed between the bites and the beginning of the treatment. Mind you keep notes of every new experiment undertaken, and write to me every other day at least."

Pasteur pondered on the means of extinguishing hydrophobia or of merely diminishing its frequency. Could dogs be vaccinated? There are 100,000 dogs in Paris, about 2,500,000 more in the provinces: vaccination necessitates several preventive inoculations; innumerable kennels would have to be built for the purpose, to say nothing of the expense of keeping the dogs and of providing a trained staff capable of performing the difficult and dangerous operations. And, as M. Nocard truly remarked,

where were rabbits to be found in sufficient number for the vaccine emulsions?

Optional vaccination did not seem more practicable; it could only be worked on a very restricted scale and was therefore of very little use in a general way.

The main question was the possibility of preventing hydrophobia from occurring in a human being, previously bitten by a rabid dog.

The Emperor of Brazil, who took the greatest interest in the doings of the Ecole Normale laboratory, having written to Pasteur asking when the preventive treatment could be applied to man, Pasteur answered as follows—

"September 22.

"SIRE—Baron Itajuba, the Minister for Brazil, has handed me the letter which Your Majesty has done me the honour of writing on August 21. The Academy welcomed with unanimous sympathy your tribute to the memory of our illustrious colleague, M. Dumas; it will listen with similar pleasure to the words of regret which you desire me to express on the subject of M. Wurtz's premature death.

"Your Majesty is kind enough to mention my studies on hydrophobia: they are making good and uninterrupted progress. I consider, however, that it will take me nearly two years more to bring them to a happy issue . . .

"What I want to do is to obtain prophylaxis of rabies *after bites*.

"Until now I have not dared to attempt anything on men, in spite of my own confidence in the result and the numerous opportunities afforded to me since my last reading at the Academy of Sciences. I fear too much that a failure might compromise the future, and I want first to accumulate successful cases on animals. Things in that direction are going very well indeed; I already have several examples of dogs made refractory after a rabietic

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bite. I take two dogs, cause them both to be bitten by a mad dog; I vaccinate the one and leave the other without any treatment: the latter dies and the first remains perfectly well.

"But even when I shall have multiplied examples of the prophylaxis of rabies in dogs, I think my hand will tremble when I go on to Mankind. It is here that the high and powerful initiative of the head of a State might intervene for the good of humanity. If I were a King, an Emperor, or even the President of a Republic, this is how I should exercise my right of pardoning criminals condemned to death. I should invite the counsel of a condemned man, on the eve of the day fixed for his execution, to choose between certain death and an experiment which would consist in several preventive inoculations of rabid virus, in order to make the subject's constitution refractory to rabies. If he survived this experiment — and I am convinced that he would—his life would be saved and his punishment commuted to a lifelong surveillance, as a guarantee towards that society which had condemned him.

"All condemned men would accept these conditions, death being their only terror.

"This brings me to the question of cholera, of which Your Majesty also has the kindness to speak to me. Neither Dr. Koch nor Drs. Straus and Roux have succeeded in giving cholera to animals, and therefore great uncertainty prevails regarding the bacillus to which Dr. Koch attributes the causation of cholera. It ought to be possible to try and communicate cholera to criminals condemned to death, by the injection of cultures of that bacillus. When the disease declared itself, a test could be made of the remedies which are counselled as apparently most efficacious.

"I attach so much importance to these measures, that, if Your Majesty shared my views, I should willingly come to

Rio Janeiro, notwithstanding my age and the state of my health, in order to undertake such studies on the prophylaxis of hydrophobia and the contagion of cholera and its remedies.

"I am, with profound respect, Your Majesty's humble and obedient servant."

In other times, the right of pardon could be exercised in the form of a chance of life offered to a criminal lending himself to an experiment. Louis XVI, having admired a fire balloon rising above Versailles, thought of proposing to two condemned men that they should attempt to go up in one. But Pilâtre des Roziers, whose ambition it was to be the first aëronaut, was indignant at the thought that "vile criminals should be the first to rise up in the air." He won his cause, and in November, 1783, he organized an ascent at the Muette which lasted twenty minutes.

In England, in the eighteenth century, before Jenner's discovery, successful attempts had been made at the direct inoculation of small-pox. In some historical and medical *Researches on Vaccine*, published in 1803, Husson relates that the King of England, wishing to have the members of his family inoculated, began by having the method tried on six criminals condemned to death; they were all saved, and the Royal Family submitted to inoculation.

There is undoubtedly a beautiful aspect of that idea of utilizing the fate of a criminal for the cause of Humanity. But in our modern laws no such liberty is left to Justice, which has no power to invent new punishments, or to enter into a bargain with a condemned criminal.

Before his departure from Arbois, Pasteur encountered fresh and unforeseen obstacles. The successful opposition of the inhabitants of Meudon had inspired those of St. Cloud, Ville d'Avray, Vaucresson, Marnes, and Garches with the idea of resisting in their turn the installation of

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Pasteur's kennels at Villeneuve l'Etang. People spoke of public danger, of children exposed to meet ferocious rabid dogs wandering loose about the park, of popular Sundays spoilt, picnickers disturbed, etc., etc.

A former pupil of Pasteur's at the Strasburg Faculty, M. Christen, now a Town Councillor at Vaucresson, warned Pasteur of all this excitement, adding that he personally was ready to do his best to calm the terrors of his townspeople.

Pasteur answered, thanking him for his efforts. ". . . I shall be back in Paris on October 24, and on the morning of the twenty-fifth and following days I shall be pleased to see any one desiring information on the subject. . . . But you may at once assure your frightened neighbours, Sir, that there will be no mad dogs at Villeneuve l'Etang, but only dogs made refractory to rabies. Not having enough room in my laboratory, I am actually obliged to quarter on various veterinary surgeons those dogs, which I should like to enclose in covered kennels, quite safely secured, you may be sure."

Pasteur, writing about this to his son, could not help saying, "Months of fine weather have been wasted! This will keep my plans back almost a year."

Little by little, in spite of the opposition which burst out now and again, calm was again re-established. French good sense and appreciation of great things got the better of the struggle; in January, 1885, Pasteur was able to go to Villeneuve l'Etang to superintend the arrangements. The old stables were turned into an immense kennel, paved with asphalte. A wide passage went from one end to the other, on each side of which accommodation for sixty dogs was arranged behind a double barrier of wire netting.

The subject of hydrophobia goes back to the remotest

antiquity ; one of Homer's warriors calls Hector a mad dog. The supposed allusions to it to be found in Hippocrates are of the vaguest, but Aristotle is quite explicit when speaking of canine rabies and of its transmission from one animal to the other through bites. He gives expression, however, to the singular opinion that man is not subject to it. More than three hundred years later we come to Celsus, who describes this disease, unknown or unnoticed until then. "The patient," said Celsus, "is tortured at the same time by thirst and by an invincible repulsion towards water." He counselled cauterization of the wound with a red-hot iron and also with various caustics and corrosives.

Pliny the Elder, a worthy precursor of village quacks, recommended the livers of mad dogs as a cure ; it was not a successful one. Galen, who opposed this, had a no less singular recipe, a compound of cray-fish eyes. Later, the shrine of St. Hubert in Belgium was credited with miraculous cures ; this superstition is still extant.

Sea bathing, unknown in France until the reign of Louis XIV, became a fashionable cure for hydrophobia, Dieppe sands being supposed to offer wonderful curing properties.

In 1780 a prize was offered for the best method of treating hydrophobia, and won by a pamphlet entitled *Dissertation sur la Rage*, written by a surgeon-major of the name of Le Roux.

This very sensible treatise concluded by recommending cauterization, now long forgotten, instead of the various quack remedies which had so long been in vogue, and the use of butter of antimony.

Le Roux did not allude in his paper to certain tenacious and cruel prejudices, which had caused several hydrophobic persons, or persons merely suspected of hydrophobia, to be killed like wild beasts, shot, poisoned, strangled, or suffocated.

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It was supposed in some places that hydrophobia could be transmitted through the mere contact of the saliva or even by the breath of the victims; people who had been bitten were in terror of what might be done to them. A girl, bitten by a mad dog and taken to the Hôtel Dieu Hospital on May 8, 1780, begged that she might not be suffocated!

Those dreadful occurrences must have been only too frequent, for, in 1810, a philosopher asked the Government to enact a Bill in the following terms: "It is forbidden, under pain of death, to strangle, suffocate, bleed to death, or in any other way murder individuals suffering from rabies, hydrophobia, or any disease causing fits, convulsions, furious and dangerous madness; all necessary precautions against them being taken by families or public authorities."

In 1819, newspapers related the death of an unfortunate hydrophobe, smothered between two mattresses; it was said à propos of this murder that "it is the doctor's duty to repeat that this disease cannot be transmitted from man to man, and that there is therefore no danger in nursing hydrophobia patients." Though old and fantastic remedies were still in vogue in remote country places, cauterization was the most frequently employed; if the wounds were somewhat deep, it was recommended to use long, sharp and pointed needles, and to push them well in, even if the wound was on the face.

One of Pasteur's childish recollections (it happened in October, 1831) was the impression of terror produced throughout the Jura by the advent of a rabid wolf who went biting men and beasts on his way. Pasteur had seen an Arboisian of the name of Nicole, being cauterized with a red-hot iron at the smithy near his father's house. The persons who had been bitten on the hands and head succumbed to hydrophobia, some of them amidst horrible sufferings; there

were eight victims in the immediate neighbourhood. Nicole was saved. For years the whole region remained in dread of that mad wolf.

The long period of incubation encouraged people to hope that some preventive means might be found, instead of the painful operation of cauterization; some doctors attempted inoculating another poison, a viper's venom for instance, to neutralize the rabic virus—needless to say with fatal results.

In 1852 a reward was promised by the Government to the finder of a remedy against hydrophobia; all the old quackeries came to light again, even Galen's remedy of cray-fish eyes!

Bouchardat, who had to report to the Academy on these remedies, considered them of no value whatever; his conclusion was that cauterization was the only prophylactic treatment of hydrophobia.

Such was also Bouley's opinion, eighteen years later, when he wrote that the object to keep in view was the quickest possible destruction of the tissues touched by rabietic saliva. Failing an iron heated to a light red heat, or the sprinkling of gunpowder over the wound and setting a match to it, he recommended caustics, such as nitric acid, sulphuric acid, hydrochloric acid, potassa fusa, butter of antimony, corrosive sublimate, and nitrate of silver.

Thus, after centuries had passed, and numberless remedies had been tried, no progress had been made, and nothing better had been found than cauterization, as indicated by Celsus in the first century.

As to the origin of rabies, it remained unknown and was erroneously attributed to divers causes. Spontaneity was still believed in. Bouley himself did not absolutely reject the idea of it, for he said in 1870: "In the immense majority

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of cases, this disease proceeds from contagion ; out of 1,000 rabid dogs, 999 at least owe their condition to inoculation by a bite."

Pasteur was anxious to uproot this fallacy, as also another very serious error, vigorously opposed by Bouley, by M. Nocard, and by another veterinary surgeon in a *Manual on Rabies*, published in 1882, and still as tenacious as most prejudices, viz., that the word hydrophobia is synonymous with rabies. The rabid dog is *not* hydrophobe, he does *not* abhor water. The word is applicable to rabid human beings, but is false concerning rabid dogs.

Many people in the country, constantly seeing Pasteur's name associated with the word rabies, fancied that he was a consulting veterinary surgeon, and pestered him with letters full of questions. What was to be done to a dog whose manner seemed strange, though there was no evidence of a suspicious bite ? Should he be shot ? "No," answered Pasteur, "shut him up securely, and he will soon die if he is really mad." Some dog owners hesitated to destroy a dog manifestly bitten by a mad dog. "It is such a good dog!" "The law is absolute," answered Pasteur ; "every dog bitten by a mad dog must be destroyed at once." And it irritated him that village mayors should close their eyes to the non-observance of the law, and thus contribute to a recrudescence of rabies.

Pasteur wasted his precious time answering all those letters. On March 28, 1885, he wrote to his friend Jules Vercel—

"Alas ! we shall not be able to go to Arbois for Easter ; I shall be busy for some time settling down, or rather settling my dogs down at Villeneuve l'Etang. I also have some new experiments on rabies on hand which will take some months. I am demonstrating this year that dogs can be vaccinated, or made refractory to rabies *after* they have been bitten by mad dogs.

"I have not yet dared to treat human beings after bites from rabid dogs; but the time is not far off, and I am much inclined to begin by myself— inoculating myself with rabies, and then arresting the consequences; for I am beginning to feel very sure of my results."

Pasteur gave more details three days later, in a letter to his son, then Secretary of the French Embassy at the Quirinal—

"The experiments before the Rabies Commission were resumed on March 10; they are now being carried out, and the Commission has already held six sittings; the seventh will take place today.

"As I only submit to it results which I look upon as acquired, this gives me a surplus of work to do; for those control experiments are added to those I am now carrying out. For I am continuing my researches, trying to discover new principles, and hardening myself by habit and by increased conviction in order to attempt preventive inoculations on man after a bite.

"The Commission's experiments have led to no result so far, for, as you know, weeks have to pass before any results occur. But no untoward incident has occurred up to now; and if all continues equally well, the Commission's second report will be as favourable as that of last year, which left nothing to be desired.

"I am equally satisfied with my new experiments in this difficult study. Perhaps practical application on a large scale may not be far off . . ."

In May, everything at Villeneuve l'Etang was ready for the reception of sixty dogs. Fifty of them, already made refractory to bites or rabic inoculation, were successively accommodated in the immense kennel, where each had his cell and his experiment number. They had been made refractory by being inoculated with fragments of medulla,

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which had hung for a fortnight in a phial, and of which the virulence was extinguished, after which further inoculations had been made, gradually increasing in virulence until the highest degree of it had again been reached.

All those dogs, which were to be periodically taken back to Paris for inoculations or bite tests, in order to see what was the duration of the immunity conferred, were stray dogs picked up by the police. They were of various breeds, and showed every variety of character, some of them gentle and affectionate, others vicious and growling, some confiding, some shrinking, as if the recollection of chloroform and the laboratory was disagreeable to them. They showed some natural impatience of their enforced captivity, only interrupted by a short daily run. One of them, however, was promoted to the post of house-dog, and loosened every night; he excited much envy among his congeners. The dogs were very well cared for by a retired *gendarme*, an excellent man of the name of Pernin.

A lover of animals might have drawn an interesting contrast between the fate of those laboratory dogs, living and dying for the good of humanity, and that of the dogs buried in the neighbouring dogs' cemetery at Bagatelle, founded by Sir Richard Wallace, the great English philanthropist. Here lay toy dogs, lap dogs, drawing-room dogs, cherished and coddled during their useless lives, and luxuriously buried after their useless deaths, while the dead bodies of the others went to the knacker's yard.

Rabbit hutches and guinea-pig cages leaned against the dogs' palace. Pasteur, having seen to the comfort of his animals, now thought of himself; it was frequently necessary that he should come to spend two or three days at Villeneuve l'Etang. The official architect thought of repairing part of the little palace of Villeneuve, which was

in a very bad state of decay. But Pasteur preferred to have some rooms near the stables put into repair, which had formerly been used for non-commissioned officers of the Cent Gardes; there was less to do to them, and the position was convenient. The roof, windows, and doors were renovated, and some cheap paper hung on the walls inside. "This is certainly not luxurious!" exclaimed an astonished millionaire, who came to see Pasteur one day on his way to his own splendid villa at Marly.

On May 29 Pasteur wrote to his son—

"I thought I should have done with rabies by the end of April; I must postpone my hopes till the end of July. Yet I have not remained stationary; but, in these difficult studies, one is far from the goal as long as the last word, the last decisive proof is not acquired. What I aspire to is the possibility of treating a man after a bite with no fear of accidents.

"I have never had so many subjects of experiment on hand—sixty dogs at Villeneuve l'Etang, forty at Rollin, ten at Frégis', fifteen at Bourrel's, and I deplore having no more kennels at my disposal.

"What do you say of the Rue Pasteur in the large city of Lille? The news has given me very great pleasure."

What Pasteur briefly called "Rollin" in this letter was the former *Lycée Rollin*, the old buildings of which had been transformed into outhouses for his laboratory. Large cages had been set up in the old courtyard, and the place was like a farm, with its population of hens, rabbits, and guinea-pigs.

Two series of experiments were being carried out on those 125 dogs. The first consisted in making dogs refractory to rabies by preventive inoculations; the second in preventing the onset of rabies in dogs bitten or subjected to inoculation.

CHAPTER VI

1885-1888

PASTEUR had the power of concentrating his thoughts to such a degree that he often, when absorbed in one idea, became absolutely unconscious of what took place around him. At one of the meetings of the Académie Française, whilst the Dictionary was being discussed, he scribbled the following note on a stray sheet of paper—

“I do not know how to hide my ideas from those who work with me; still, I wish I could have kept those I am going to express a little longer to myself. The experiments have already begun which will decide them.

“It concerns rabies, but the results might be general.

“I am inclined to think that the virus which is considered rabic may be accompanied by a substance which, by impregnating the nervous system, would make it unsuitable for the culture of the microbe. Thence vaccinal immunity. If that is so, the theory might be a general one: it would be a stupendous discovery.

“I have just met Chamberland in the Rue Gay-Lussac, and explained to him this view and my experiments. He was much struck, and asked my permission to make at once on anthrax the experiment I am about to make on rabies as soon as the dog and the culture rabbits are dead. Roux, the day before yesterday, was equally struck.

“*Académie Française, Thursday, January 29, 1885.*”

Could that vaccinal substance associated with the rabic virus be isolated? In the meanwhile a main fact was acquired, that of preventive inoculation, since Pasteur was sure of his series of dogs rendered refractory to rabies after a bite. Months were going by without bringing an answer to the question "Why?" of the antirabic vaccination, as mysterious as the "Why?" of Jennerian vaccination.

On the Monday, July 6, Pasteur saw a little Alsatian boy, Joseph Meister, enter his laboratory, accompanied by his mother. He was only nine years old, and had been bitten two days before by a mad dog at Meissengott, near Schlestadt.

The child, going alone to school by a little by-road, had been attacked by a furious dog and thrown to the ground. Too small to defend himself, he had only thought of covering his face with his hands. A bricklayer, seeing the scene from a distance, arrived, and succeeded in beating the dog off with an iron bar; he picked up the boy, covered with blood and saliva. The dog went back to his master, Théodore Vone, a grocer at Meissengott, whom he bit on the arm. Vone seized a gun and shot the animal, whose stomach was found to be full of hay, straw, pieces of wood, etc. When little Meister's parents heard all these details they went, full of anxiety, to consult Dr. Weber, at Villé, that same evening. After cauterizing the wounds with carbolic, Dr. Weber advised Mme. Meister to start for Paris, where she could relate the facts to one who was not a physician, but who would be the best judge of what could be done in such a serious case. Théodore Vone, anxious on his own and on the child's account, decided to come also.

Pasteur reassured him; his clothes had wiped off the dog's saliva, and his shirt-sleeve was intact. He might safely go back to Alsace, and he promptly did so.

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Pasteur's emotion was great at the sight of the fourteen wounds of the little boy, who suffered so much that he could hardly walk. What should he do for this child? could he risk the preventive treatment which had been constantly successful on his dogs? Pasteur was divided between his hopes and his scruples, painful in their acuteness. Before deciding on a course of action, he made arrangements for the comfort of this poor woman and her child, alone in Paris, and gave them an appointment for 5 o'clock, after the Institute meeting. He did not wish to attempt anything without having seen Vulpian and talked it over with him. Since the Rabies Commission had been constituted, Pasteur had formed a growing esteem for the great judgment of Vulpian, who, in his lectures on the general and comparative physiology of the nervous system, had already mentioned the profit to human clinics to be drawn from experimenting on animals.

His was a most prudent mind, always seeing all the aspects of a problem. The man was worthy of the scientist: he was absolutely straightforward, and of a discreet and active kindness. He was passionately fond of work, and had recourse to it when smitten by a deep sorrow.

Vulpian expressed the opinion that Pasteur's experiments on dogs were sufficiently conclusive to authorize him to foresee the same success in human pathology. Why not try this treatment? added the professor, usually so reserved. Was there any other efficacious treatment against hydrophobia? If at least the cauterizations had been made with a red-hot iron! but what was the good of carbolic acid twelve hours after the accident. If the almost certain danger which threatened the boy were weighed against the chances of snatching him from death, Pasteur would see that it was more than a right, that it was a duty to apply antirabic inoculation to little Meister.

This was also the opinion of Dr. Grancher, whom Pasteur consulted. M. Grancher worked at the laboratory ; he and Dr. Straus might claim to be the two first French physicians who took up the study of bacteriology ; these novel studies fascinated him, and he was drawn to Pasteur by the deepest admiration and by a strong affection, which Pasteur thoroughly reciprocated.

Vulpian and M. Grancher examined little Meister in the evening, and, seeing the number of bites, some of which, on one hand especially, were very deep, they decided on performing the first inoculation immediately ; the substance chosen was fourteen days old and had quite lost its virulence : it was to be followed by further inoculations gradually increasing in strength.

It was a very slight operation, a mere injection into the side (by means of a Pravaz syringe) of a few drops of a liquid prepared with some fragments of medulla oblongata. The child, who cried very much before the operation, soon dried his tears when he found the slight prick was all that he had to undergo.

Pasteur had had a bedroom comfortably arranged for the mother and child in the old Rollin College, and the little boy was very happy amidst the various animals—chickens, rabbits, white mice, guinea-pigs, etc. ; he begged and easily obtained of Pasteur the life of several of the youngest of them.

"All is going well," Pasteur wrote to his son-in-law on July 11 : "the child sleeps well, has a good appetite, and the inoculated matter is absorbed into the system from one day to another without leaving a trace. It is true that I have not yet come to the test inoculations, which will take place on Tuesday, Wednesday and Thursday. If the lad keeps well during the three following weeks, I think the experiment will be safe to succeed. I shall send the child

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and his mother back to Meissengott (near Schlestadt) in any case on August 1, giving these good people detailed instruction as to the observations they are to record for me. I shall make no statement before the end of the vacation."

But, as the inoculations were becoming more virulent, Pasteur became a prey to anxiety: "My dear children," wrote Mme. Pasteur, "your father has had another bad night; he is dreading the last inoculations on the child. And yet there can be no drawing back now! The boy continues in perfect health."

Renewed hopes were expressed in the following letter from Pasteur—

"My dear René, I think great things are coming to pass. Joseph Meister has just left the laboratory. The three last inoculations have left some pink marks under the skin, gradually widening and not at all tender. There is some action, which is becoming more intense as we approach the final inoculation, which will take place on Thursday, July 16. The lad is very well this morning, and has slept well, though slightly restless; he has a good appetite and no feverishness. He had a slight hysterical attack yesterday."

The letter ended with an affectionate invitation. "Perhaps one of the great medical facts of the century is going to take place; you would regret not having seen it!"

Pasteur was going through a succession of hopes, fears, anguish, and an ardent yearning to snatch little Meister from death; he could no longer work. At nights, feverish visions came to him of this child whom he had seen playing in the garden, suffocating in the mad struggles of hydrophobia, like the dying child he had seen at the Hôpital Trousseau in 1880. Vainly his experimental genius assured him that the virus of that most terrible of diseases

was about to be vanquished, that humanity was about to be delivered from this dread horror—his human tenderness was stronger than all, his accustomed ready sympathy for the sufferings and anxieties of others was for the nonce centred in “the dear lad.”

The treatment lasted ten days; Meister was inoculated twelve times. The virulence of the medulla used was tested by trephining on rabbits, and proved to be gradually stronger. Pasteur even inoculated on July 16, at 11 a.m., some medulla only one day old, bound to give hydrophobia to rabbits after only seven days’ incubation; it was the surest test of the immunity and preservation due to the treatment.

Cured from his wounds, delighted with all he saw, gaily running about as if he had been in his own Alsatian farm, little Meister, whose blue eyes now showed neither fear nor shyness, merrily received the last inoculation; in the evening, after claiming a kiss from “Dear Monsieur Pasteur,” as he called him, he went to bed and slept peacefully. Pasteur spent a terrible night of insomnia; in those slow dark hours of night when all vision is distorted, Pasteur, losing sight of the accumulation of experiments which guaranteed his success, imagined that the little boy would die.

The treatment being now completed, Pasteur left little Meister to the care of Dr. Grancher (the lad was not to return to Alsace until July 27) and consented to take a few days’ rest. He spent them with his daughter in a quiet, almost deserted country place in Burgundy, but without however finding much restfulness in the beautiful peaceful scenery; he lived in constant expectation of Dr. Grancher’s daily telegram or letter containing news of Joseph Meister.

By the time he went to the Jura, Pasteur’s fears had almost disappeared. He wrote from Arbois to his son

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August 3, 1885: "Very good news last night of the bitten lad. I am looking forward with great hopes to the time when I can draw a conclusion. It will be thirty-one days tomorrow since he was bitten."

On August 20, six weeks before the new elections of Deputies, Léon Say, Pasteur's colleague at the Académie Française, wrote to him that many Beauce agricultors were anxious to put his name down on the list of candidates, as a recognition of the services rendered by science. A few months before, Jules Simon had thought Pasteur might be elected as a Life Senator, but Pasteur had refused to be convinced. He now replied to Léon Say—

"Your proposal touches me very much, and it would be agreeable to me to owe a Deputy's mandate to electors, several of whom have applied the results of my investigations. But politics frighten me and I have already refused a candidature in the Jura and a seat in the Senate in the course of this year.

"I might be tempted perhaps, if I no longer felt active enough for my laboratory work. But I still feel equal to further researches, and on my return to Paris, I shall be organizing a 'service' against rabies which will absorb all my energies. I now possess a very perfect method of prophylaxis against that terrible disease, a method equally adapted to human beings and to dogs, and by which your much afflicted Department will be one of the first to benefit.

"Before my departure for Jura I dared to treat a poor little nine-year-old lad whose mother brought him to me from Alsace, where he had been attacked on the 4th ult., and bitten on the thighs, legs, and hand in such a manner that hydrophobia would have been inevitable. He remains in perfect health."

Whilst many political speeches were being prepared, Pasteur was thinking over a literary speech. He had been requested by the Académie Française to welcome Joseph Bertrand, elected in place of J. B. Dumas—the eulogium of a scientist, spoken by one scientist, himself welcomed by another scientist. This was an unusual programme for the Académie Française, perhaps too unusual in the eyes of Pasteur, who did not think himself worthy of speaking in the name of the Académie. Such was his modesty ; he forgot that amongst the *savants* who had been members of the Académie, several, such as Fontenelle, Cuvier, J. B. Dumas, etc., had published immortal pages, and that some extracts from his own works would one day become classical.

The vacation gave him time to read over the writings of his beloved teacher, and also to study the life and works of Joseph Bertrand, already his colleague at the Académie des Sciences.

Bertrand's election had been simple and easy, like everything he had undertaken since his birth. It seemed as if a good fairy had leant over his cradle and whispered to him, "Thou shalt know many things, without having had to learn them." It is a fact that he could read without having held a book in his hands. He was ill and in bed whilst his brother Alexander was being taught to read ; he listened to the lessons and kept the various combinations of letters in his mind. When he became convalescent, his parents brought him a book of Natural History so that he might look at the pictures. He took the volume and read from it fluently ; he was not five years old. He learnt the elements of geometry very much in the same way.

Pasteur in his speech thus described Joseph Bertrand's childhood : "At ten years old you were already celebrated,

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and it was prophesied that you would pass at the head of the list into the Ecole Polytechnique and become a member of the Academy of Science. No one doubted this, not even yourself. You were indeed a child prodigy. Sometimes it amused you to hide in a class of higher mathematics, and when the Professor propounded a difficult problem that no one could solve, one of the students would triumphantly lift you in his arms, stand you on a chair so that you might reach the board, and you would then give the required solution with a calm assurance, in the midst of applause from the professors and pupils."

Pasteur, whose every progress had been painfully acquired, admired the ease with which Bertrand had passed through the first stages of his career. At an age when marbles and indiarubber balls are usually an important interest, Bertrand walked merrily to the *Jardin des Plantes* to attend a course of lectures by Gay-Lussac. A few hours later, he might be seen at the Sorbonne, listening with interest to Saint Marc Girardin, the literary moralist. The next day, he would go to a lecture on Comparative Legislation; never was so young a child seen in such serious places. He borrowed as many books from the Institute library as Biot himself; he learnt whole passages by heart, merely by glancing at them. He became a *doctor ès sciences* at sixteen, and a Member of the Institute at thirty-four.

Besides his personal works—such as those on Analytic Mechanics, which place him in the very first rank—his teaching had been brought to bear during forty years on all branches of mathematics. Bertrand's life, apparently so happy, had been saddened by the irreparable loss, during the Commune, of a great many precious notes, letters, and manuscripts, which had been burnt with the house where he had left them. Discouraged by this ruin of ten years'

work, he had given way to a tendency to writing slight popular articles, of high literary merit, instead of continuing his deeper scientific work. His eulogy of J. B. Dumas was not quite seriously enthusiastic enough to please Pasteur, who had a veritable cult for the memory of his old teacher, and who eagerly grasped this opportunity of speaking again of J. B. Dumas' influence on himself, of his admirable scientific discoveries, and of his political duties, undertaken in the hope of being useful to Science, but often proving a source of disappointment.

Pasteur enjoyed looking back on the beloved memory of J. B. Dumas, as he sat preparing his speech in his study at Arbois, looking out on the familiar landscape of his childhood, where the progress of practical science was evidenced by the occasional passing, through the distant pine woods, of the white smoke of the Switzerland express.

When in his laboratory in Paris, Pasteur hated to be disturbed whilst making experiments or writing out notes of his work. Any visitor was unwelcome; one day that some one was attempting to force his way in, M. Roux was amused at seeing Pasteur—vexed at being disturbed and anxious not to pain the visitor—come out to say imploringly, “Oh! not now, please! I am too busy!”

“When Chamberland and I,” writes Dr. Roux, “were engaged in an interesting occupation, he mounted guard before us, and when, through the glazed doors, he saw people coming, he himself would go and meet them in order to send them away. He showed so artlessly that his sole thought was for the work, that no one ever could be offended.”

But, at Arbois, where he only spent his holidays, he did not exercise so much severity; any one could come in who liked. He received in the morning a constant stream of visitors, begging for advice, recommendations, interviews, etc.

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"It is both comical and touching," wrote M. Girard, a local journalist, "to see the opinion the vineyard labourers have of him. These good people have heard M. Pasteur's name in connection with the diseases of wine, and they look upon him as a sort of wine doctor. If they notice a barrel of wine getting sour, they knock at the savant's door, bottle in hand; this door is never closed to them. Peasants are not precise in their language; they do not know how to begin their explanations or how to finish them. M. Pasteur, ever calm and serious, listens to the very end, takes the bottle and studies it at his leisure. A week later, the wine is 'cured.'"

He was consulted also on many other subjects—virus, silkworms, rabies, cholera, swine-fever, etc.; many took him for a physician. Whilst telling them of their mistake, he yet did everything he could for them.

During this summer of 1885, he had the melancholy joy of seeing a bust erected in the village of Monay to the memory of a beloved friend of his, J. J. Perraud, a great and inspired sculptor, who had died in 1876. Perraud, whose magnificent statue of Despair is now at the Louvre, had had a sad life, and, on his lonely death-bed (he was a widower, with no children), Pasteur's tender sympathy had been an unspeakable comfort. Pasteur now took a leading part in the celebration of his friend's fame, and was glad to speak to the assembled villagers at Monay of the great and disinterested artist who had been born in their midst.

On his return to Paris, Pasteur found himself obliged to hasten the organization of a "service" for the preventive treatment of hydrophobia after a bite. The Mayor of Villers-Farlay, in the Jura, wrote to him that, on October 14, a shepherd had been cruelly bitten by a rabid dog.

Six little shepherd boys were watching over their sheep in a meadow; suddenly they saw a large dog passing along the road, with hanging, foaming jaws.

"A mad dog!" they exclaimed. The dog, seeing the children, left the road and charged them; they ran away shrieking, but the eldest of them, J. B. Jupille, fourteen years of age, bravely turned back in order to protect the flight of his comrades. Armed with his whip, he confronted the infuriated animal, who flew at him and seized his left hand. Jupille wrestling with the dog, succeeded in kneeling on him, and forcing its jaws open in order to disengage his left hand; in so doing, his right hand was seriously bitten in its turn; finally, having been able to get hold of the animal by the neck, Jupille called to his little brother to pick up his whip, which had fallen during the struggle, and securely fastened the dog's jaws with the lash. He then took his wooden *sabot*, with which he battered the dog's head, after which, in order to be sure that it could do no further harm, he dragged the body down to a little stream in the meadow, and held the head under water for several minutes. Death being now certain, and all danger removed from his comrades, Jupille returned to Villers-Farlay.

Whilst the boy's wounds were being bandaged, the dog's carcase was fetched, and a necropsy took place the next day. The two veterinary surgeons who examined the body had not the slightest hesitation in declaring that the dog was rabid.

The Mayor of Villers-Farlay, who had been to see Pasteur during the summer, wrote to tell him that this lad would die a victim of his own courage unless the new treatment intervened. The answer came immediately: Pasteur declared that, after five years' study, he had succeeded in making dogs refractory to rabies, even six or eight days after being bitten; that he had only once yet

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applied his method to a human being, but that once with success, in the case of little Meister, and that, if Jupille's family consented, the boy might be sent to him. "I shall keep him near me in a room of my laboratory; he will be watched and need not go to bed; he will merely receive a daily prick, not more painful than a pin-prick."

The family, on hearing this letter, came to an immediate decision; but, between the day when he was bitten and Jupille's arrival in Paris, six whole days had elapsed, whilst in Meister's case there had only been two and a half!

Yet, however great were Pasteur's fears for the life of this tall lad, who seemed quite surprised when congratulated on his courageous conduct, they were not what they had been in the first instance—he felt much greater confidence.

A few days later, on October 26, Pasteur in a statement at the Academy of Sciences described the treatment followed for Meister. Three months and three days had passed, and the child remained perfectly well. Then he spoke of his new attempt. Vulpian rose—

"The Academy will not be surprised," he said, "if, as a member of the Medical and Surgical Section, I ask to be allowed to express the feelings of admiration inspired in me by M. Pasteur's statement. I feel certain that those feelings will be shared by the whole of the medical profession.

"*Hydrophobia*, that dread disease against which all therapeutic measures had hitherto failed, has at last found a remedy. M. Pasteur, who has been preceded by no one in this path, has been led, by a series of investigations unceasingly carried on for several years, to create a method of treatment, by means of which the development of hydrophobia can *infallibly* be prevented in a patient recently bitten by a rabid dog. I say infallibly, because, after what I have seen in M. Pasteur's laboratory, I do not doubt the

constant success of this treatment when it is put into full practice a few days only after a rabic bite.

"It is now necessary to see about organizing an installation for the treatment of hydrophobia by M. Pasteur's method. Every person bitten by a rabid dog must be given the opportunity of benefiting by this great discovery, which will seal the fame of our illustrious colleague and bring glory to our whole country."

Pasteur had ended his reading by a touching description of Jupille's action, leaving the Assembly under the impression of that boy of fourteen, sacrificing himself to save his companions. An Academician, Baron Larrey, whose authority was rendered all the greater by his calmness, dignity, and moderation, rose to speak. After acknowledging the importance of Pasteur's discovery, Larrey continued, "The sudden inspiration, agility and courage, with which the ferocious dog was muzzled, and thus made incapable of committing further injury to bystanders, . . . such an act of bravery deserves to be rewarded. I therefore have the honour of begging the Académie des Sciences to recommend to the Académie Française this young shepherd, who, by giving such a generous example of courage and devotion, has well deserved a Montyon prize.

Bouley, then chairman of the Academy, rose to speak in his turn—

"We are entitled to say that the date of the present meeting will remain for ever memorable in the history of medicine, and glorious for French science; for it is that of one of the greatest steps ever accomplished in the medical order of things—a progress realized by the discovery of an efficacious means of preventive treatment for a disease, the incurable nature of which was a legacy handed down by one century to another. From this day, humanity is armed with a means of fighting the fatal

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disease of hydrophobia and of preventing its onset. It is to M. Pasteur that we owe this, and we could not feel too much admiration or too much gratitude for the efforts on his part which have led to such a magnificent result. . . ."

Five years previously, Bouley, in the annual combined public meeting of the five Academies, had proclaimed his enthusiasm for the discovery of the vaccination of anthrax. But on hearing him again on this October day, in 1885, his colleagues could not but be painfully struck by the change in him ; his voice was weak, his face thin and pale. He was dying of an affection of the heart, and quite aware of it, but he was sustained by a wonderful energy, and ready to forget his sufferings in his joy at the thought that the sum of human sorrows would be diminished by Pasteur's victory. He went to the Académie de Médecine the next day to enjoy the echo of the great sitting of the Académie des Sciences. He died on November 29.

The chairman of the Academy of Medicine, M. Jules Bergeron, applauded Pasteur's statement all the more that he too had publicly deplored (in 1862) the impotence of medical science in the presence of this cruel disease.

But while M. Bergeron shared the admiration felt by Vulpian and Dr. Grancher for the experiments which had transformed the rabid virus into its own vaccine, other medical men were divided into several categories: some were full of enthusiasm, others reserved their opinion, many were sceptical, and a few even positively hostile.

As soon as Pasteur's paper was published, people bitten by rabid dogs began to arrive from all sides to the laboratory. The "service" of hydrophobia became the chief business of the day. Every morning was spent by Eugène Viala in preparing the fragments of marrow used for inoculations: in a little room permanently kept at a temperature of 20° to 23° C., stood rows of sterilized flasks,

their tubular openings closed by plugs of cotton-wool. Each flask contained a rabic marrow, hanging from the stopper by a thread and gradually drying up by the action of some fragments of caustic potash lying at the bottom of the flask. Viala cut those marrows into small pieces by means of scissors previously put through a flame, and placed them in small sterilized glasses ; he then added a few drops of veal broth and pounded the mixture with a glass rod. The vaccinal liquid was now ready ; each glass was covered with a paper cover, and bore the date of the medulla used, the earliest of which was fourteen days old. For each patient under treatment from a certain date, there was a whole series of little glasses. Pasteur always attended these operations personally.

In the large hall of the laboratory, Pasteur's collaborators, Messrs. Chamberland and Roux, carried on investigations into contagious diseases under the master's directions ; the place was full of flasks, pipets, phials, containing culture broths. Etienne Wassergug, another curator, hardly more than a boy, fresh from the Ecole Normale, where his bright intelligence and affectionate heart had made him very popular, translated (for he knew the English, German, Italian, Hungarian and Spanish languages, and was awaiting a favourable opportunity of learning Russian) the letters which arrived from all parts of the world; he also entertained foreign scientists. Pasteur had in him a most valuable interpreter. Physicians came from all parts of the world asking to be allowed to study the details of the method. One morning, Dr. Grancher found Pasteur listening to a physician who was gravely and solemnly holding forth his objections to microbian doctrines, and in particular to the treatment of hydrophobia. Pasteur having heard this long monologue, rose and said, "Sir, your language is not very intelligible to me. I am not a

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physician and do not desire to be one. Never speak to me of your dogma of morbid spontaneity. I am a chemist; I carry out experiments and I try to understand what they teach me. What do you think, doctor?" he added, turning to M. Grancher. The latter smilingly answered that the hour for inoculations had struck. They took place at eleven, in Pasteur's study; he standing by the open door, called out the names of the patients. The date and circumstances of the bites and the veterinary surgeon's certificate were entered in a register, and the patients were divided into series according to the degree of virulence which was to be inoculated on each day of the period of treatment.

Pasteur took a personal interest in each of his patients, helping those who were poor and illiterate to find suitable lodgings in the great capital. Children especially inspired him with a loving solicitude. But his pity was mingled with terror, when, on November 9, a little girl of ten was brought to him who had been severely bitten on the head by a mountain dog, on October 3, thirty-seven days before!! The wound was still suppurating. He said to himself, "This is a hopeless case: hydrophobia is no doubt about to appear immediately; it is much too late for the preventive treatment to have the least chance of success. Should I not, in the scientific interest of the method, refuse to treat this child? If the issue is fatal, all those who have already been treated will be frightened, and many bitten persons, discouraged from coming to the laboratory, may succumb to the disease!" These thoughts rapidly crossed Pasteur's mind. But he found himself unable to resist his compassion for the father and mother, begging him to try and save their child.

After the treatment was over, Louise Pelletier had returned to school, when fits of breathlessness appeared,

soon followed by convulsive spasms; she could swallow nothing. Pasteur hastened to her side when these symptoms began, and new inoculations were attempted. On December 2, there was a respite of a few hours, moments of calm which inspired Pasteur with the vain hope that she might yet be saved. This delusion was a short-lived one. After attending Bouley's funeral, his heart full of sorrow, Pasteur spent the day by little Louise's bedside, in her parents' rooms in the Rue Dauphine. He could not tear himself away ; she herself, full of affection for him, gasped out a desire that he should not go away, that he should stay with her ! She felt for his hand between two spasms. Pasteur shared the grief of the father and mother. When all hope had to be abandoned : "I did so wish I could have saved your little one !" he said. And as he came down the staircase, he burst into tears.

He was obliged, a few days later, to preside at the reception of Joseph Bertrand at the Académie Française ; his sad feelings little in harmony with the occasion. He read in a mournful and troubled voice the speech he had prepared during his peaceful and happy holidays at Arbois. Henry Houssaye, reporting on this ceremony in the *Journal de Débats*, wrote, "M. Pasteur ended his speech amidst a torrent of applause, he received a veritable ovation. He seemed unaccountably moved. How can M. Pasteur, who has received every mark of admiration, every supreme honour, whose name is consecrated by universal renown, still be touched by anything save the discoveries of his powerful genius." People did not realize that Pasteur's thoughts were far away from himself and from his brilliant discovery. He was thinking of Dumas, his master, of Bouley, his faithful friend and colleague, and of the child he had been unable to snatch from the jaws of death ; his mind was not with the living, but with the dead.

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A telegram from New York having announced that four children, bitten by rabid dogs, were starting for Paris, many adversaries who had heard of Louise Pelletier's death were saying triumphantly that, if those children's parents had known of her fate, they would have spared them so long and useless a journey.

The four little Americans belonged to workmen's families and were sent to Paris by means of a public subscription opened in the columns of the *New York Herald*; they were accompanied by a doctor and by the mother of the youngest of them, a boy only five years old. After the first inoculation, this little boy, astonished at the insignificant prick, could not help saying, "Is this all we have come such a long journey for?" The children were received with enthusiasm on their return to New York, and were asked "many questions about the great man who had taken such care of them."

A letter dated from that time (January 14, 1886) shows that Pasteur yet found time for kindness, in the midst of his world-famed occupations.

"My dear Jupille, I have received your letters, and I am much pleased with the news you give me of your health. Mme. Pasteur thanks you for remembering her. She, and every one at the laboratory, join with me in wishing that you may keep well and improve as much as possible in reading, writing and arithmetic. Your writing is already much better than it was, but you should take some pains with your spelling. Where do you go to school? Who teaches you? Do you work at home as much as you might? You know that Joseph Meister, who was first to be vaccinated, often writes to me; well, I think he is improving more quickly than you are, though he is only ten years old. So, mind you take pains, do not waste your time with other boys, and listen to the advice of your

teachers, and of your father and mother. Remember me to M. Perrot, the Mayor of Villers-Farlay. Perhaps, without him, you would have become ill, and to be ill of hydrophobia means inevitable death; therefore you owe him much gratitude. Good-bye. Keep well."

Pasteur's solicitude did not confine itself to his two first patients, Joseph Meister and the fearless Jupille, but was extended to all those who had come under his care; his kindness was like a living flame. The very little ones who then only saw in him a "kind gentleman" bending over them, understood later in life, when recalling the sweet smile lighting up his serious face, that Science, thus understood, unites moral with intellectual grandeur.

Good, like evil, is infectious; Pasteur's science and devotion inspired an act of generosity which was to be followed by many others. He received a visit from one of his colleagues at the Académie Française, Edouard Hervé, who looked upon journalism as a great responsibility and as a school of mutual respect between adversaries. He was bringing to Pasteur, from the Comte de Laubespain, a generous philanthropist, a sum of 40,000 fr. destined to meet the expenses necessitated by the organization of the hydrophobia treatment. Pasteur, when questioned by Hervé, answered that his intention was to found a model establishment in Paris, supported by donations and international subscriptions, without having recourse to the State. But he added that he wanted to wait a little longer until the success of the treatment was undoubted. Statistics came to support it; Bouley, who had been entrusted with an official inquiry on the subject under the Empire, had found that the proportion of deaths after bites from rabid dogs had been 40 per 100, 320 cases having been watched. The proportion often was greater still: whilst Joseph Meister

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was under Pasteur's care, five persons were bitten by a rabid dog on the Pantin Road, near Paris, and every one of them succumbed to hydrophobia.

Pasteur, instead of referring to Bouley's statistics, preferred to adopt those of M. Leblanc, a veterinary surgeon and a member of the Academy of Medicine, who had for a long time been head of the sanitary department of the *Préfecture de Police*. These statistics only gave a proportion of deaths of 16 per 100, and had been carefully and accurately kept.

On March 1, he was able to affirm, before the Academy, that the new method had given proofs of its merit, for, out of 350 persons treated, only one death had taken place, that of the little Pelletier. He concluded thus—

"It may be seen, by comparison with the most rigorous statistics, that a very large number of persons have already been saved from death.

"The prophylaxis of hydrophobia after a bite is established.

"It is advisable to create a vaccinal institute against hydrophobia."

The Academy of Science appointed a Commission who unanimously adopted the suggestion that an establishment for the preventive treatment of hydrophobia after a bite should be created in Paris, under the name of *Institut Pasteur*. A subscription was about to be opened in France and abroad. The spending of the funds would be directed by a special Committee.

A great wave of enthusiasm and generosity swept from one end of France to another and reached foreign countries. A newspaper of Milan, the *Perseveranza*, which had opened a subscription, collected 6,000 fr. in its first list. The *Journal d'Alsace* headed a propaganda in favour of this work, "sprung from Science and Charity." It reminded its

readers that Pasteur had occupied a professor's chair in the former brilliant Faculty of Science of Strasburg, and that his first inoculation was made on an Alsatian boy, Joseph Meister. The newspaper intended to send the subscriptions to Pasteur with these words: "Offerings from Alsace-Lorraine to the Pasteur Institute."

The war of 1870 still darkened the memories of nations. Amongst eager and numerous inventions of instruments of death and destruction, humanity breathed when fresh news came from the laboratory, where a continued struggle was taking place against diseases. The most mysterious, the most cruel of all was going to be reduced to impotence.

Yet the method was about to meet with a few more cases like Louise Pelletier's; accidents would result, either from delay or from exceptionally serious wounds. Happy days were still in store for those who sowed doubt and hatred.

During the early part of March, Pasteur received nineteen Russians, coming from the province of Smolensk. They had been attacked by a rabid wolf and most of them had terrible wounds: one of them, a priest, had been surprised by the infuriated beast as he was going into church, his upper lip and right cheek had been torn off, his face was one gaping wound. Another, the youngest of them, had had the skin of his forehead torn off by the wolf's teeth; other bites were like knife cuts. Five of these unhappy wretches were in such a condition that they had to be carried to the Hôtel Dieu hospital as soon as they arrived.

The Russian doctor who had accompanied these mujiks related how the wolf had wandered for two days and two nights, tearing to pieces every one he met, and how he had

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finally been struck down with an axe by one of those he had bitten most severely.

Because of the gravity of the wounds, and in order to make up for the time lost by the Russians before they started, Pasteur decided on making two inoculations every day, one in the morning and one in the evening; the patients at the Hôtel Dieu could be inoculated upon at the hospital.

The fourteen others came every morning in their *touloupes* and fur caps, with their wounds bandaged, and joined without a word the motley groups awaiting treatment at the laboratory—an English family, a Basque peasant, a Hungarian in his national costume, etc., etc.

In the evening, the dumb and resigned band of mujiks came again to the laboratory door. They seemed led by Fate, heedless of the struggle between life and death of which they were the prize. "Pasteur" was the only French word they knew, and their set and melancholy faces brightened in his presence as with a ray of hope and gratitude.

Their condition was the more alarming that a whole fortnight had elapsed between their being bitten and the date of the first inoculations. Statistics were terrifying as to the results of wolf-bites, the average proportion of deaths being 82 per 100. General anxiety and excitement prevailed concerning the hapless Russians, and the news of the death of three of them produced an intense emotion.

Pasteur had unceasingly continued his visits to the Hôtel Dieu. He was overwhelmed with grief. His confidence in his method was in no wise shaken, the general results would not allow it. But questions of statistics were of little account in his eyes when he was the witness of a misfortune; his charity was not of that kind which is exhausted by collective generalities: each individual appealed to his heart. As he passed through the wards at

the Hôtel Dieu, each patient in his bed inspired him with deep compassion. And that is why so many who only saw him pass, heard his voice, met his pitiful eyes resting on them, have preserved of him a memory such as the poor had of St. Vincent de Paul.

"The other Russians are keeping well so far," declared Pasteur at the Academy sitting of April 12, 1886. Whilst certain opponents in France continued to discuss the three deaths and apparently saw nought but those failures, the return of the sixteen survivors was greeted with an almost religious emotion. Other Russians had come before them and were saved, and the Tsar, knowing these things, desired his brother, the Grand Duke Vladimir, to bring to Pasteur an imperial gift, the Cross of the Order of St. Anne of Russia, in diamonds. He did more, he gave 100,000 fr. in aid of the proposed Pasteur Institute.

In April, 1886, the English Government, seeing the practical results of the method for the prophylaxis of hydrophobia, appointed a Commission to study and verify the facts. Sir James Paget was the president of it, and the other members were:—Dr. Lauder-Brunton, Mr. Fleming, Sir Joseph Lister, Dr. Quain, Sir Henry Roscoe, Professor Burdon Sanderson, and Mr. Victor Horsley, secretary. The *résumé* of the programme was as follows—

Development of the rabic virus in the medulla oblongata of animals dying of rabies.

Transmission of this virus by subdural or subcutaneous inoculation.

Intensification of this virus by successive passages from rabbit to rabbit.

Possibility either of protecting healthy animals from ulterior bites from rabid animals, or of preventing the onset of rabies in animals already bitten, by means of vaccinal inoculations.

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Applications of this method to man and value of its results.

Burdon Sanderson and Horsley came to Paris, and two rabbits, inoculated on by Pasteur, were taken to England; a series of experiments was to be begun on them, and an inquiry was to take place afterwards concerning patients treated both in France and in England. Pasteur, who lost his temper at prejudices and ill-timed levity, approved and solicited inquiry and careful examination.

Long lists of subscribers appeared in the *Journal Officiel*—millionaires, poor workmen, students, women, etc. A great festival was organized at the Trocadéro in favour of the Pasteur Institute; the greatest artistes offered their services. Coquelin recited verses written for the occasion which excited loud applause from the immense audience. Gounod, who had conducted his *Ave Maria*, turned round after the closing bars, and, in an impulse of heartfelt enthusiasm, kissed both his hands to the *savant*.

In the evening at a banquet, Pasteur thanked his colleagues and the organizers of this incomparable performance. "Was it not," he said, "a touching sight, that of those immortal composers, those great charmers of fortunate humanity coming to the assistance of those who wish to study and to serve suffering humanity? And you too come, great artistes, great actors, like so many generals re-entering the ranks to give greater vigour to a common feeling. I cannot easily describe what I felt. Dare I confess that I was hearing most of you for the first time? I do not think I have spent more than ten evenings of my whole life at a theatre. But I can have no regrets now that you have given me, in a few hours' interval, as in an exquisite synthesis, the feelings that so many others scatter over several months, or rather several years."

A few days later, the subscription from Alsace-Lorraine

brought in 43,000 fr. Pasteur received it with grateful emotion, and was pleased and touched to find the name of little Joseph Meister among the list of private subscribers. It was now eleven months since he had been bitten so cruelly by the dog, whose rabic condition had immediately been recognized by the German authorities. Pasteur ever kept a corner of his heart for the boy who had caused him such anxiety.

Pasteur's name was now familiar to all those who were trying to benefit humanity; his presence at charitable gatherings was considered as a happy omen, and he was asked to preside on many such occasions. He was ever ready with his help and sympathy, speaking in public, answering letters from private individuals, giving wholesome advice to young people who came to him for it, and doing nothing by halves. If he found the time, even during that period when the study of rabies was absorbing him, to undertake so many things and to achieve so many tasks, he owed it to Mme. Pasteur, who watched over his peace, keeping him safe from intrusions and interruptions. This retired, almost recluse life, enabled him to complete many works, a few of which would have sufficed to make several scientists celebrated.

Every morning, between ten and eleven o'clock, Pasteur walked down the Rue Claude-Bernard to the Rue Vauquelin, where a few temporary buildings had been erected to facilitate the treatment of hydrophobia, close to the rabbit hutches, hen-coops, and dog kennels which occupied the yard of the old Collège Rollin. The patients under treatment walked about cheerfully amidst these surroundings, looking like holiday makers in a Zoological Garden. Children, whose tears were already dried at the second inoculation, ran about merrily. Pasteur, who loved the

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little ones, always kept sweets or new copper coins for them in his drawer. One little girl amused herself by having holes bored in those coins, and hung them round her neck like a necklace ; she was wearing this ornament on the day of her departure, when she ran to kiss the great man as she would have kissed her grandfather.

Drs. Grancher, Roux, Chantemesse, and Charrin came by turns to perform the inoculations. A surgery ward had been installed to treat the numerous wounds of the patients, and entrusted to the young and energetic Dr. Terrillon.

In August, 1886, while staying at Arbois, Pasteur spent much time over his notes and registers ; he was sometimes tempted to read over certain articles of passionate criticism. "How difficult it is to obtain the triumph of truth!" he would say. "Opposition is a useful stimulant, but bad faith is such a pitiable thing. How is it that they are not struck with the results as shown by statistics ? From 1880 to 1885, sixty persons are stated to have died of hydrophobia in the Paris hospitals ; well, since November 1, 1885, when the prophylactic method was started in my laboratory, only three deaths have occurred in those hospitals, two of which were cases which had not been treated. It is evident that very few people who had been bitten did not come to be treated. In France, out of that unknown but very restricted number, seventeen cases of death have been noted, whilst out of the 1,726 French and Algerians who came to the laboratory only ten died after the treatment."

But Pasteur was not yet satisfied with this proportion, already so low ; he was trying to forestall the outburst of hydrophobia by a greater rapidity and intensity of the treatment. He read a paper on the subject to the Academy of Science on November 2, 1886. Admiral Jurien de la Gravière, who was in the chair, said to him, "All great

discoveries have gone through a time of trial. May your health withstand the troubles and difficulties in your way."

Pasteur's health had indeed suffered from so much work and anxiety, and there were symptoms of some heart trouble. Drs. Villemin and Grancher persuaded him to interrupt his work and to think of spending a restful winter in the south of France. M. Raphael Bischoffsheim, a great lover of science, placed at Pasteur's disposal his beautiful villa at Bordighera, close to the French frontier, which he had on divers occasions lent to other distinguished guests, the Queen of Italy, Henri Sainte-Claire Deville, Gambetta, etc.

Pasteur consented to leave his work at the end of November, and started one evening from the Gare de Lyon with his wife, his daughter and her husband, and his two grandchildren; eighteen friends came to the station to see him off, including his pupils, M. Bischoffsheim, and some foreign physicians, who were staying in Paris to study the prophylactic treatment of hydrophobia.

The bright dawn and the sunshine already appearing at Avignon contrasted with the foggy November weather left behind in Paris and brought a feeling of comfort, almost of returning health; a delegation of doctors met the train at Nice, bringing Pasteur their good wishes.

The travelling party drove from Vintimille to Bordighera under the deep blue sky reflected in a sea of a yet deeper blue, along a road bordered with cacti, palms and other tropical plants. The sight of the lovely gardens of the Villa Bischoffsheim gave Pasteur a delicious feeling of rest.

His health soon improved sufficiently for him to be able to take some short walks. But his thoughts constantly recurred to the laboratory. M. Duclaux was then thinking of starting a monthly periodical entitled *Annals of the*

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Pasteur Institute. Pasteur, writing to him on December 27, 1887, to express his approbation, suggested various experiments to be attempted. He attributed the action of the preventive inoculations to a vaccinal matter associated with the rabic microbe. Pasteur had thought at first that the first development of the pathogenic microbe caused the disappearance from the organism of an element necessary to the life of that microbe. It was, in other words, a theory of exhaustion. But since 1885, he adopted the other idea, supported indeed by biologists, that immunity was due to a substance left in the body by the culture of the microbe and which opposed the invasion—a theory of addition.

"I am happy to learn," wrote Villemin, his friend and his medical adviser, "that your health is improving; continue to rest in that beautiful country, you have well deserved it, and rest is *absolutely* necessary to you. You have overtaxed yourself beyond all reason and you must make up for it. Repairs to the nervous system are worked chiefly by relaxation from the mental storms and moral anxieties which your *rabid* work has occasioned in you. Give the Bordighera sun a chance!"

But Pasteur was not allowed the rest he so much needed; on January 4, 1887, referring to a death which had occurred after treatment in the preceding December, M. Peter declared that the antirabic cure was useless; at the following meeting he called it dangerous when applied in the "intensive" form. Dujardin-Beaumetz, Chauveau and Verneuil immediately intervened, declaring that the alleged fact was "devoid of any scientific character." A week later, MM. Grancher and Brouardel bore the brunt of the discussion. Grancher, Pasteur's representative on this occasion, disproved certain allegations, and added: "The medical men who have been chosen by M. Pasteur to assist him in his work have not hesitated to practise the

antirabic inoculation on themselves, as a safeguard against an accidental inoculation of the virus which they are constantly handling. What greater proof can they give of their bonâ fide convictions?" He showed that the mortality amongst the cases treated remained below 1 per 100. "M. Pasteur will soon publish foreign statistics from Samara, Moscow, St. Petersburg, Odessa, Warsaw and Vienna: they are all absolutely favourable."

As it was insinuated that the laboratory of the Ecole Normale kept its failures a secret, it was decided that the *Annals of the Pasteur Institute* would publish a monthly list and bulletin of patients under treatment.

Vulpian, at another meeting (it was almost the last time he was heard at the Académie de Médecine) said, à propos of what he called an inexcusable opposition, "This new benefit adds to the number of those which our illustrious Pasteur has already rendered to humanity. . . . Our works and our names will soon be buried under the rising tide of oblivion: the name and the works of M. Pasteur will continue to stand on heights too great to be reached by its sullen waves." Pasteur was much disturbed by the noise of these discussions; every post increased his feverishness, and he spoke every morning of returning to Paris to answer his opponents.

It was a pitiful thing to note on his worn countenance the visible signs of the necessity of the peace and rest offered by this beautiful land of serene sunshine, and to hear at the same time a constant echo of those angry debates. Anonymous letters were sent to him, insulting newspaper articles—all that envy and hatred can invent; the seamy side of human nature was being revealed to him. "I did not know I had so many enemies," he said mournfully. He was consoled to some extent by the ardent support of the greatest medical men in France.

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Vulpian, in a statement to the Académie des Sciences, constituted himself Pasteur's champion. Pasteur indeed was safe from attacks in that centre, but certain low slanderers who attended the public meetings of the Académie continued to accuse Pasteur of concealing the failures of his method. Vulpian—who was furiously angry at such an insinuation against “a man like M. Pasteur, whose good faith, loyalty and scientific integrity should be an example to his adversaries as they are to his friends”—thought that it was in the interest both of science and of humanity, to state once more the facts recently confirmed by new statistics; the public is so impressionable and so mobile in its opinions that one article is often enough to shake general confidence. He was therefore anxious to reassure all those who had been inoculated on and who might be induced by those discussions to wonder with anguish whether they really were saved. The Academy of Science decided that Vulpian's statement should be inserted *in extenso* in all the reports and a copy of it sent to every village in France. Vulpian wrote to Pasteur at the same time, “All your admirers hope that those interested attacks will merely excite your contempt. Fine weather is no doubt reigning at Bordighera: you must take advantage of it and become quite well. . . . The Academy of Medicine is almost entirely on your side; there are at the most but four or five exceptions.

Pasteur had a few calm days after these debates. Whilst planning out new investigations, he was much interested in the plans for his Institute which were now submitted to him. His thoughts were always away from Bordighera, which he seemed to look upon as a sort of exile. This impression was partly due to the situation of the town, so close to the frontier, and the haunt of so many homeless wanderers. He once met a sad-faced, still

beautiful woman, in mourning robes, and recognized the Empress Eugénie.

Shortly afterwards, he received a visit from Prince Napoleon, who dragged his haughty *ennui* from town to town. He presented himself at the Villa Bischoffsheim under the name of Count Moncalieri, coming, he said, to greet his colleague of the Institute. Rabies formed the subject of their conversation. The next day, Pasteur called on the Prince, in his commonplace hotel rooms, a mere temporary resting place for the exiled Bonaparte, whose mysterious, uncompleted destiny was made more enigmatical by his startling resemblance to the great Emperor.

On February 23, the day after the carnival, early in the morning, a violent earthquake cast terror over that peaceful land where nature hides with flowers the spectre of death. At 6.20 a.m. a low and distant rumbling sound was heard, coming from the depths of the earth and resembling the noise of a train passing in an underground tunnel ; houses began to rock and ominous cracks were heard. This first shock lasted more than a minute, during which the sense of solidity disappeared altogether, to be succeeded by a feeling of absolute, hopeless, impotence. No doubt, in every household, families gathered together, with a sudden yearning not to be divided. Pasteur's wife, children and grandchildren had barely had time to come to him when another shock took place, more terrible than the first ; everything seemed about to be engulfed in an abyss. Never had morning been more radiant, there was not a breath of wind, the air was absolutely transparent.

An early departure was necessary : the broken ceilings were dropping to pieces, shaken off by an incessant vibration of the ground which continued after the second shock, and of which Pasteur observed the effect on glass windows with much interest. Pasteur and his family drove off to

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Vintimille in a carriage, along a road lined with ruined houses, crowded with sick people in quest of carriages and peasants coming down from their mountain dwellings, destroyed by the shock, leading donkeys loaded with bedding, the women followed by little children hastily wrapt in blankets and odd clothes. At Vintimille station, terrified travellers were trying to leave France for Italy or Italy for France, fancying that the danger would cease on the other side of the frontier.

"We have resolved to go to Arbois," wrote Mme. Pasteur to her son from Marseilles ; "your father will be better able there than anywhere else to recover from this shock to his heart."

After a few weeks' stay at Arbois, Pasteur seemed quite well again. He was received with respect and veneration on his return to the Academies of Sciences and of Medicine. His best and greatest colleagues had realized what the loss of him would mean to France and to the world, and surrounded him with an anxious solicitude.

At the beginning of July, Pasteur received the report presented to the House of Commons by the English Commission after a fourteen months' study of the prophylactic method against hydrophobia. The English scientists had verified every one of the facts upon which the method was founded, but they had not been satisfied with their experimental researches in Mr. Horsley's laboratory, and had carried out a long and minute inquiry in France. After noting on Pasteur's registers the names of ninety persons treated, who had come from the same neighbourhood, they had interviewed each one of them in their own homes. "It may therefore be considered as certain"—thus ran the report—"that M. Pasteur has discovered a prophylactic method against hydrophobia which may be compared with that of vaccination against small-pox. It

would be difficult to overestimate the utility of this discovery, both from the point of view of its practical side and of its application to general pathology. We have here a new method of inoculation, or vaccination, as M. Pasteur sometimes calls it, and similar means might be employed to protect man and domestic animals against other virus as active as that of hydrophobia."

Pasteur laid this report on the desk of the Academy of Sciences on July 4. He spoke of its spirit of entire and unanimous confidence, and added—

"Thus fall to the ground the contradictions which have been published. I leave on one side the passionate attacks which were not justified by the least attempt at experiment, the slightest observation of facts in my laboratory, or even an exchange of words and ideas with the Director of the Hydrophobia Clinic, Professor Grancher, and his medical assistants.

"But, however deep is my satisfaction as a Frenchman, I cannot but feel a sense of deepest sadness at the thought that this high testimony from a commission of illustrious scientists, was not known by him who, at the very beginning of the application of this method, supported me by his counsels and his authority, and who later on, when I was ill and absent, knew so well how to champion truth and justice; I mean our beloved colleague Vulpian."

Vulpian had succumbed to a few days' illness. His speech in favour of Pasteur was almost the farewell to the Academy of this great-hearted scientist.

The discussion threatened to revive. Other colleagues defended Pasteur at the Academy of Medicine on July 12. Professor Brouardel spoke, also M. Villemin, and then Charcot, who insisted on quoting word for word Vulpian's true and simple phrase: "The discovery of the preventive treatment of hydrophobia after a bite, entirely due to M.

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Pasteur's experimental genius, is one of the finest discoveries ever made, both from the scientific and the humanitarian point of view." And Charcot continued: "I am persuaded that I express in these words the opinion of all the medical men who have studied the question with an open mind, free from prejudice; the inventor of antirabic vaccination may, now more than ever, hold his head high and continue to accomplish his glorious task, heedless of the clamour of systematic contradiction or of the insidious murmurs of slander."

The Academy of Sciences begged Pasteur to become its Life Secretary in Vulpian's place. Pasteur did not reply at once to this offer, but went to see M. Berthelot: "This high position," he said, "would be more suitable to you than to me." M. Berthelot, much touched, refused unconditionally, and Pasteur accepted. He was elected on July 18. He said, in thanking his colleagues, "I would now spend what time remains before me, on the one hand in encouraging to research and in training for scientific studies,—the future of which seems to me most promising,—pupils worthy of French science; and, on the other hand, in following attentively the work incited and encouraged by this Academy.

"Our only consolation, as we feel our own strength failing us, is to feel that we may help those who come after us to do more and to do better than ourselves, fixing their eyes as they can on the great horizons of which we only had a glimpse."

He did not long fulfil his new duties. On October 23, Sunday morning, after writing a letter in his room, he tried to speak to Mme. Pasteur and could not pronounce a word; his tongue was paralysed. He had promised to lunch with his daughter on that day, and, fearing that she might be alarmed, he drove to her house. After spending a few

hours in an easy chair, he consented to remain at her house with Mme. Pasteur. In the evening his speech returned, and two days later, when he went back to the Ecole Normale, no one would have noticed any change in him. But, on the following Saturday morning, he had another almost similar attack, without any premonitory symptoms. His speech remained somewhat difficult, and his deep powerful voice completely lost its strength. In January, 1888, he was obliged to resign his secretaryship.

Ill health had emaciated his features. A portrait of him by Carolus Duran represents him looking ill and weary, a sad look in his eyes. But goodness predominates in those worn features, revealing that lovable soul, full of pity for all human sufferings, and of which the painter has rendered the unspeakable thrill.

Pasteur's various portraits, compared with one another, show us different aspects of his physiognomy. A luminous profile, painted by Henner ten years before, brings out the powerful harmony of the forehead. In 1886, Bonnat painted, for the brewer Jacobsen, who wished to present it to Mme. Pasteur, a large portrait which may be called an official one. Pasteur is standing in rather an artificial attitude, which might be imperious, if his left hand was not resting on the shoulder of his granddaughter, a child of six, with clear pensive eyes. In that same year, Edelfeldt, the Finnish painter, begged to be allowed to come into the laboratory for a few sketches. Pasteur came and went, attending to his work and taking no notice of the painter. One day that Edelfeldt was watching him thus, deep in observation, his forehead lined with almost painful thoughts, he undertook to portray the *savant* in his meditative attitude. Pasteur is standing clad in a short brown coat, an experimental card in his left hand, in his right, a phial containing a fragment of rabic marrow, the

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expression in his eyes entirely concentrated on the scientific problem.

During the year 1888, Pasteur, after spending the morning with his patients, used to go and watch the buildings for the Pasteur Institute which were being erected in the Rue Dutot. 11,000 square yards of ground had been acquired in the midst of some market gardens. Instead of rows of hand-lights and young lettuces, a stone building, with a Louis XIII façade, was now being constructed. An interior gallery connected the main building with the large wings. The Pasteur Institute was to be at the same time a great dispensary for the treatment of hydrophobia, a centre of research on virulent and contagious diseases, and also a teaching centre. M. Duclaux's class of biological chemistry, held at the Sorbonne, was about to be transferred to the Pasteur Institute, where Dr. Roux would also give a course of lectures on technical microbia. The "service" of vaccinations against anthrax was entrusted to M. Chamberland. (The statistics of 1882-1887 gave a total of 1,600,000 sheep and nearly 200,000 oxen.) There would also be, under M. Metchnikoff's direction, some private laboratories, the monkish cells of the Pastorians.

At the end of October, the work was almost completed; Pasteur invited the President of the Republic to come and inaugurate the Institute. "I shall certainly not fail to do so," answered Carnot; "your Institute is a credit to France."

On November 14, politicians, colleagues, friends, collaborators, pupils assembled in the large library of the new Institute. Pasteur had the pleasure of seeing before him, in the first rank, Duruy and Jules Simon; it was a great day for these former Ministers of Public Instruction. Like them, Pasteur had all his life been deeply interested in higher education. "If that teaching is but for a small

number," he said, "it is with this small number, this élite that the prosperity, glory and supremacy of a nation rests."

Joseph Bertrand, chairman of the Institute Committee, knowing that by so doing he responded to Pasteur's dearest wishes, spoke of the past and recalled the memories of Biot, Senarmont, Claude Bernard, Balard, and J. B. Dumas.

Professor Grancher, Secretary of the Committee, alluded to the way in which not only Vulpian but Brouardel, Charcot, Verneuil, Chauveau and Villemin had recently honoured themselves by supporting the cause of progress and preparing its triumph. These memories of early friends, associated with that of recent champions, brought before the audience a vision of the procession of years. After speaking of the obstacles Pasteur had so often encountered amongst the medical world—

" You know," said M. Grancher, " that M. Pasteur is an innovator, and that his creative imagination, kept in check by rigorous observation of facts, has overturned many errors and built up in their place an entirely new science. His discoveries on ferments, on the generation of the infinitesimally small, on microbes, the cause of contagious diseases, and on the vaccination of those diseases, have been for biological chemistry, for the veterinary art and for medicine, not a regular progress, but a complete revolution. Now, revolutions, even those imposed by scientific demonstration, ever leave behind them vanquished ones who do not easily forgive. M. Pasteur has therefore many adversaries in the world, without counting those Athenian French who do not like to see one man always right or always fortunate. And, as if he had not enough adversaries, M. Pasteur makes himself new ones by the rigorous implacability of his dialectics and the absolute form he sometimes gives to his thought."

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Going on to the most recently acquired results, M. Grancher stated that the mortality amongst persons treated after bites from rabid dogs remained under 1 per 100.

"If those figures are indeed eloquent," said M. Christophe, the treasurer, who spoke after M. Grancher, "other figures are touching. I would advise those who only see the dark side of humanity," he remarked, before entering upon the statement of accounts—"those who go about repeating that everything here below is for the worst, that there is no disinterestedness, no devotion in this world—to cast their eyes over the 'human documents' of the Pasteur Institute. They would learn therein, beginning at the beginning, that Academies contain colleagues who are not offended, but proud and happy in the fame of another; that politicians and journalists often have a passion for what is good and true; that at no former epoch have great men been more beloved in France; that justice is already rendered to them during their lifetime, which is very much the best way of doing so; that we have cheered Victor Hugo's birthday, Chevreul's centenary, and the inauguration of the Pasteur Institute. When a Frenchman runs himself down, said one of M. Pasteur's colleagues, do not believe him; he is boasting! Reversing a celebrated and pessimistic phrase, it might be said that in this public subscription all the virtues flow into unselfishness like rivers into the sea."

M. Christophe went on to show how rich and poor had joined in this subscription and raised an amount of 2,586,680 fr. The French Chambers had voted 200,000 fr., to which had been added international gifts from the Tsar, the Emperor of Brazil, and the Sultan. The total expenses would probably reach 1,563,786 fr., leaving a little more than a million to form an endowment for the Pasteur Institute, a fund which was to be increased every year by the product of the sale of vaccines from the laboratory,

which Pasteur and Messrs. Chamberland and Roux agreed to give up to the Institute.

"It is thus, Sir," concluded the treasurer, directly addressing Pasteur, "that public generosity, practical help from the Government, and your own disinterestedness have founded and consolidated the establishment which we are to-day inaugurating." And, persuaded that the solicitude of the public would never fail to support this great work, "This is for you, Sir, a rare and almost un hoped for happiness; let it console you for the passionate struggles, the terrible anxiety and the many emotions you have gone through."

Pasteur, overcome by his feelings, had to ask his son to read his speech. It began by a rapid summary of what France had done for education in all its degrees. "From village schools to laboratories, everything has been founded or renovated." After acknowledging the help given him in later years by the public authorities, he continued—

"And when the day came that, foreseeing the future which would be opened by the discovery of the attenuation of virus, I appealed to my country, so that we should be allowed, through the strength and impulse of private initiative, to build laboratories to be devoted, not only to the prophylactic treatment of hydrophobia, but also to the study of virulent and contagious diseases—on that day again, France gave in handfuls. . . . It is now finished, this great building, of which it might be said that there is not a stone but what is the material sign of a generous thought. All the virtues have subscribed to build this dwelling place for work.

"Alas! mine is the bitter grief that I enter it, a man 'vanquished by Time,' deprived of my masters, even of my companions in the struggle, Dumas, Bouley, Paul Bert, and lastly Vulpian, who, after having been with you, my dear

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Grancher, my counsellor at the very first, became the most energetic, the most convinced champion of this method.

"However, if I have the sorrow of thinking that they are no more, after having valiantly taken their part in discussions which I have never provoked but have had to endure ; if they cannot hear me proclaim all that I owe to their counsels and support ; if I feel their absence as deeply as on the morrow of their death, I have at least the consolation of believing that all that we struggled for together will not perish. The collaborators and pupils who are now here share our scientific faith. . . ." He continued, as in a sort of testament : "Keep your early enthusiasm, dear collaborators, but let it ever be regulated by rigorous examinations and tests. Never advance anything which cannot be proved in a simple and decisive fashion.

"Worship the spirit of criticism. If reduced to itself, it is not an awakener of ideas or a stimulant to great things, but, without it, everything is fallible ; it always has the last word. What I am now asking you, and you will ask of your pupils later on, is what is most difficult to an inventor.

"It is indeed a hard task, when you believe you have found an important scientific fact and are feverishly anxious to publish it, to constrain yourself for days, weeks, years sometimes, to fight with yourself, to try and ruin your own experiments and only to proclaim your discovery after having exhausted all contrary hypotheses.

"But when, after so many efforts, you have at last arrived at a certainty, your joy is one of the greatest which can be felt by a human soul, and the thought that you will have contributed to the honour of your country renders that joy still deeper.

"If science has no country, the scientist should have one, and ascribe to it the influence which his works may have

in this world. If I might be allowed, M. le Président, to conclude by a philosophical remark inspired by your presence in this Home of Work, I should say that two contrary laws seem to be wrestling with each other nowadays; the one, a law of blood and of death, ever imagining new means of destruction and forcing nations to be constantly ready for the battlefield—the other, a law of peace, work and health, ever evolving new means of delivering man from the scourges which beset him.

“The one seeks violent conquests, the other the relief of humanity. The latter places one human life above any victory; while the former would sacrifice hundreds and thousands of lives to the ambition of one. The law of which we are the instruments seeks, even in the midst of carnage, to cure the sanguinary ills of the law of war; the treatment inspired by our antiseptic methods may preserve thousands of soldiers. Which of those two laws will ultimately prevail, God alone knows. But we may assert that French Science will have tried, by obeying the law of Humanity, to extend the frontiers of Life.”

CHAPTER VII

1889-1895

IN this Institute, which Pasteur entered ill and weary, he contemplated with joy those large laboratories, which would enable his pupils to work with ease and to attract around them investigators from all countries. He was happy to think that the material difficulties which had hampered him would be spared those who came after him. He believed in the realization of his wishes for peace, work, mutual help among men. Whatever the obstacles, he was persuaded that science would continue its civilizing progress and that its benefits would spread from domain to domain. Differing from those old men who are ever praising the past, he had an enthusiastic confidence in the future; he foresaw great developments of his studies, some of which were already apparent. His first researches on crystallography and molecular dissymmetry had served as a basis to stereo-chemistry. But, while he followed the studies on that subject of Le Bel and Van T'Hoff, he continued to regret that he had not been able to revert to the studies of his youth, enslaved as he had been by the inflexible logical sequence of his works. "Every time we have had the privilege of hearing Pasteur speak of his early researches," writes M. Chamberland, in an article of the *Revue Scientifique*, "we have seen the revival in him of a smouldering fire, and we have thought that his coun-

tenance showed a vague regret at having forsaken them. Who can now say what discoveries he might have made in that direction?" "One day," said Dr. Héricourt—who spent the summer near Villeneuve l'Etang, and who often came into the Park with his two sons—"he favoured me with an admirable, captivating discourse on this subject, the like of which I have never heard."

Pasteur, instead of feeling regret, might have looked back with calm pride on the progress he had made in other directions.

In what obscurity were fermentation and infection enveloped before his time, and with what light he had penetrated them! When he had discovered the all-powerful rôle of the infinitesimally small, he had actually mastered some of those living germs, causes of disease; he had transformed them from destructive to preservative agents. Not only had he renovated medicine and surgery, but hygiene, misunderstood and neglected until then, was benefiting by the experimental method. Light was being thrown on preventive measures.

M. Henri Monod, Director of Hygiene and Public Charities, one day quoted, à propos of sanitary measures, these words of the great English minister, Disraeli—

"Public health is the foundation upon which rest the happiness of the people and the power of the State. Take the most beautiful kingdom, give it intelligent and laborious citizens, prosperous manufactures, productive agriculture; let arts flourish, let architects cover the land with temples and palaces; in order to defend all these riches, have first-rate weapons, fleets of torpedo boats—if the population remains stationary, if it decreases yearly in vigour and in stature, the nation must perish. And that is why I consider that the first duty of a statesman is the care of Public Health."

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In 1889, when the International Congress of Hygiene met in Paris, M. Brouardel was able to say—

“If echoes from this meeting could reach them . . . our ancestors would learn that a revolution, the most formidable for thirty centuries, has shaken medical science to its very foundations, and that it is the work of a stranger to their corporation; and their sons do not cry Anathema, they admire him, bow to his laws. . . . We all proclaim ourselves disciples of Pasteur.”

On the very day after those words were pronounced, Pasteur saw the realization of one of his most ardent wishes, the inauguration of the new Sorbonne. At the sight of the wonderful facilities for work offered by this palace, he remembered Claude Bernard’s cellar, his own garret at the Ecole Normale, and felt a movement of patriotic pride.

In October, 1889, though his health remained shaken, he insisted on going to Alais, where a statue was being raised to J. B. Dumas. Many of his colleagues tried to dissuade him from this long and fatiguing journey, but he said: “I am alive, I shall go.” At the foot of the statue, he spoke of his master, one of those men who are “the tutelary spirits of a nation.”

The sericultors, desiring to thank him for the five years he had spent in studying the silkworm disease, offered him an artistic souvenir: a silver heather twig laden with gold cocoons.

Pasteur did not fail to remind them that it was at the request of their fellow-citizen that he had studied pébrine. He said: “In the expression of your gratitude, by which I am deeply touched, do not forget that the initiative was due to M. Dumas.”

Thus his character revealed itself on every occasion. Every morning, with a step rendered heavy by age and

ill-health, he went from his rooms to the Hydrophobia Clinic, arriving there long before the patients. He superintended the preparation of the vaccinal marrows; no detail escaped him. When the time came for inoculations, he was already informed of each patient's name, sometimes of his poor circumstances; he had a kind word for every one, often substantial help for the very poor. The children interested him most; whether severely bitten, or frightened at the inoculation, he dried their tears and consoled them. How many children have thus kept a memory of him! "When I see a child," he used to say, "he inspires me with two feelings: tenderness for what he is now, respect for what he may become hereafter."

Already in May, 1892, Denmark, Sweden, and Norway had formed various Committees of scientists and pupils of Pasteur to celebrate his seventieth birthday. In France, it was in November that the Medical and Surgical Section of the Academy of Sciences constituted a Subscription Committee to offer Pasteur an affectionate homage. Roty, the celebrated engraver, was desired to finish a medal he had already begun, representing Pasteur in profile, a skull cap on his broad forehead, the brow strongly prominent, the whole face full of energy and meditation. His shoulders are covered with the cape he usually wore in the morning in the passages of his Institute. Roty had not time to design a satisfactory reverse side; he surrounded with laurels and roses the following inscription: "To Pasteur, on his seventieth birthday. France and Humanity grateful."

On the morning of December 27, 1892, the great theatre of the Sorbonne was filled. The seats of honour held the French and foreign delegates from scientific Societies, the members of the Institute, and the Professors of Faculties. In the amphitheatre were the deputations from the Ecoles

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Normale, Polytechnique, Centrale, of Pharmacy, Vétérinaires, and of Agriculture—deep masses of students. People pointed out to each other Pasteur's pupils, Messrs. Duclaux, Roux, Chamberland, Metchnikoff, in their places; M. Perdrix, a former Normalien, now an *Agrégué-préparateur*; M. Edouard Calmette, a former student of the Ecole Centrale, who had taken part in the studies on beer; and M. Denys Cochin, who, thirteen years before, had studied alcoholic fermentation in the laboratory of the Rue d'Ulm. The first gallery was full of those who had subscribed towards the presentation about to be made to Pasteur. In the second gallery, boys from *lycées* crowned the immense assembly with a youthful garland.

At half-past 10 o'clock, whilst the band of the Republican Guard played a triumphal march, Pasteur entered, leaning on the arm of the President of the Republic. Carnot led him to a little table, whereon the addresses from the various delegates were to be laid. The Presidents of the Senate and of the Chamber, the Ministers and Ambassadors, took their seats on the platform. Behind the President of the Republic stood, in their uniform, the official delegates of the five Academies which form the Institut de France. The Academy of Medicine and the great Scientific Societies were represented by their presidents and life-secretaries.

M. Charles Dupuy, Minister of Public Instruction, rose to speak, and said, after retracing Pasteur's great works—

"Who can now say how much human life owes to you and how much more it will owe to you in the future! The day will come when another Lucretius will sing, in a new poem on Nature, the immortal Master whose genius engendered such benefits.

"He will not describe him as a solitary, unfeeling man, like the hero of the Latin poet; but he will show him mingling with the life of his time, with the joys and trials

of his country, dividing his life between the stern enjoyment of scientific research and the sweet communion of family intercourse; going from the laboratory to his hearth, finding in his dear ones, particularly in the helpmeet who has understood him so well and loved him all the better for it, that comforting encouragement of every hour and each moment, without which so many struggles might have exhausted his ardour, arrested his perseverance, and enervated his genius. . . .

"May France keep you for many more years, and show you to the world as the worthy object of her love, of her gratitude and pride."

The President of the Academy of Sciences, M. d'Abbadie, was chosen to present to Pasteur the commemorative medal of this great day.

Joseph Bertrand said that the same science, wide, accurate, and solid, had been a foundation to all Pasteur's works, each of them shining "with such a dazzling light, that, in looking at either, one is inclined to think that it eclipses all others."

After a few words from M. Daubrée, senior member of the Mineralogical Section and formerly a colleague of Pasteur's at the Strasburg Faculty, the great Lister, who represented the Royal Societies of London and Edinburgh, brought to Pasteur the homage of medicine and surgery. "You have," said he, "raised the veil which for centuries had covered infectious diseases; you have discovered and demonstrated their microbial nature."

When Pasteur rose to embrace Lister, the sight of those two men gave the impression of a brotherhood of science labouring to diminish the sorrows of humanity.

After a speech from M. Bergeron, Life-Secretary of the Academy of Medicine, and another from M. Sauton, President of the Paris Municipal Council, the various delegates

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presented the addresses they had brought. Each of the large cities of Europe had its representative. The national delegates were called in their turn. A student from the Alfort Veterinary School brought a medal offered by the united Veterinary Schools of France. Amongst other offerings, Pasteur was given an album containing the signatures of the inhabitants of Arbois, and another coming from Dôle, in which were reproduced a facsimile of his birth-certificate and a photograph of the house in which he was born. The sight of his father's signature at the end of the certificate moved him more than anything else.

The Paris Faculty of Medicine was represented by its Dean, Professor Brouardel. "More fortunate than Harvey and than Jenner," he said, "you have been able to see the triumph of your doctrines, and what a triumph! . . ."

The last word of homage was pronounced by M. Devise, President of the Students' Association, who said to Pasteur, "You have been very great and very good; you have given a beautiful example to students."

Pasteur's voice, made weaker than usual by his emotion, could not have been heard all over the large theatre; his thanks were read out by his son—

"Monsieur le Président de la République, your presence transforms an intimate fête into a great ceremony, and makes of the simple birthday of a *savant* a special date for French science.

"M. le Ministre, Gentlemen—In the midst of all this magnificence, my first thought takes me back to the melancholy memory of so many men of science who have known but trials. In the past, they had to struggle, against the prejudices which hampered their ideas. After those prejudices were vanquished, they encountered obstacles and difficulties of all kinds.

"Very few years ago, before the public authorities and

the town councils had endowed science with splendid dwellings, a man whom I loved and admired, Claude Bernard, had, for a laboratory, a wretched cellar not far from here, low and damp. Perhaps it was there that he contracted the disease of which he died. When I heard what you were preparing for me here, the thought of him arose in my mind; I hail his great memory.

"Gentlemen, by an ingenious and delicate thought, you seem to make the whole of my life pass before my eyes. One of my Jura compatriots, the Mayor of Dôle, has brought me a photograph of the very humble home where my father and mother lived such a hard life. The presence of the students of the Ecole Normale brings back to me the glamour of my first scientific enthusiasms. The representatives of the Lille Faculty evoke memories of my first studies on crystallography and fermentation, which opened to me a new world. What hopes seized upon me when I realized that there must be laws behind so many obscure phenomena! You, my dear colleagues, have witnessed by what series of deductions it was given to me, a disciple of the experimental method, to reach physiological studies. If I have sometimes disturbed the calm of our Academies by somewhat violent discussions, it was because I was passionately defending truth.

"And you, delegates from foreign nations, who have come from so far to give to France a proof of sympathy, you bring me the deepest joy that can be felt by a man whose invincible belief is that Science and Peace will triumph over Ignorance and War, that nations will unite, not to destroy, but to build, and that the future will belong to those who will have done most for suffering humanity. I appeal to you, my dear Lister, and to you all, illustrious representatives of medicine and surgery.

"Young men, have confidence in those powerful and safe

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methods, of which we do not yet know all the secrets. And, whatever your career may be, do not let yourselves become tainted by a deprecating and barren scepticism, do not let yourselves be discouraged by the sadness of certain hours which pass over nations. Live in the serene peace of laboratories and libraries. Say to yourselves first: ‘What have I done for my instruction?’ and, as you gradually advance, ‘What have I done for my country?’ until the time comes when you may have the immense happiness of thinking that you have contributed in some way to the progress and to the good of humanity. But, whether our efforts are or not favoured by life, let us be able to say, when we come near the great goal, ‘I have done what I could.’

“Gentlemen, I would express to you my deep emotion and hearty gratitude. In the same way as Roty, the great artist, has, on the back of this medal, hidden under roses the heavy number of years which weigh on my life, you have, my dear colleagues, given to my old age the most delightful sight of all this living and loving youth.”

The shouts “Vive Pasteur!” resounded throughout the building. The President of the Republic rose, went towards Pasteur to congratulate him, and embraced him with effusion.

Hearts went out to Pasteur even from distant countries. The Canadian Government, acting on the suggestion of the deputies of the province of Quebec, gave the name of Pasteur to a district on the borders of the state of Maine.

A few weeks after the fête, the Governor-General of Algeria, M. Cambon, wrote to Pasteur as follows—

“Sir—desirous of showing to you the special gratitude which Algeria bears you for the immense services you have rendered to science and to humanity by your great and fruit-

ful discoveries, I have decided that your name should be given to the village of Sériana, situated in the *arrondissement* of Batna, department of Constantine. I am happy that I have been able to render this slight homage to your illustrious person." "I feel a deep emotion," replied Pasteur, "in thinking that, thanks to you, my name will remain attached to that corner of the world. When a child of this village asks what was the origin of this denomination, I should like the schoolmaster to tell him simply that it is the name of a Frenchman who loved France very much, and who, by serving her, contributed to the good of humanity. My heart is thrilled at the thought that my name might one day awaken the first feelings of patriotism in a child's soul. I shall owe to you this great joy in my old age; I thank you more than I can say." The origin of Sériana is very ancient. M. Stéphane Gsell relates that this village was occupied long before the coming of the Romans, by a tribe which became Christian, as is seen by ruins of chapels and basilicas. It is situated on the slope of a mountain covered with oaks and cedars, and giving rise to springs of fresh water. A bust of Pasteur was soon after erected in this village, at the request of the inhabitants.

Enthusiasm for Pasteur was spreading everywhere. Women understood that science was entering their domain, since it served charity. They gave magnificent gifts; clauses in wills bore these words: "To Pasteur, to help in his humanitarian task." In November, 1893, Pasteur saw an unknown lady enter his study in the Rue Dutot, and heard her speak thus: "There must be some students who love science and who, having to earn their living, cannot give themselves up to disinterested work. I should like to place at your disposal four scholarships, for four young men chosen by you. Each scholarship would be of 3,000 frs.; 2,400 for the men themselves, and 600 frs. for the expenses

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they would incur in your laboratories. Their lives would be rendered easier. You could find amongst them, either an immediate collaborator for your Institute or a missionary whom you might send far away; and if a medical career tempted them, they would be enabled by their momentary independence to prepare themselves all the better for their profession. I only ask one thing, which is that my name should not be mentioned."

Pasteur was infinitely touched by the scheme of this mysterious lady. The scholarship foundation was for one year only, but other years were about to follow and to resemble this one.

Many letters brought to Pasteur requested that he should study or order the study of such and such a disease. Some of these letters responded to preoccupations which had long been in the mind of Pasteur and his disciples. One day he received these lines:

"You have done all the good a man could do on earth. If you will, you can surely find a remedy for the horrible disease called diphtheria. Our children, to whom we teach your name as that of a great benefactor, will owe their lives to you.—A MOTHER."

Pasteur, in spite of his failing strength, had hopes that he would yet live to see the defeat of the foe so dreaded by mothers. In the laboratory of the Pasteur Institute, Dr. Roux and Dr Yersin were obstinately pursuing the study of this disease. In their first paper on the subject, modestly entitled *A Contribution to the Study of Diphtheria*, they said: "Ever since Bretonneau, diphtheria has been looked upon as a specific and contagious disease; its study has therefore been undertaken of late years with the help of the microbial methods which have already been the means of finding the cause of many other infectious diseases."

In spite of the convictions of Bretonneau, who had, in 1818, witnessed a violent epidemic of croup in the centre of France, his view was far from being generally adopted. Velpeau, then a young student, wrote to him in 1820 that all the members, save two, of the Faculty of Medicine were agreed in opposing or blaming his opinions. Another brilliant pupil of Bretonneau's, Dr. Trousseau, who never ceased to correspond with his old master, wrote to him in 1854: "It remains to be proved that diphtheria always comes from a germ. I hardly doubt this with regard to small-pox; to be consistent, I ought not to doubt it either with regard to diphtheria. I was thinking so this morning, as I was performing tracheotomy on a poor child twenty-eight months old; opposite the bed, there was a picture of his five-year-old brother, painted on his death-bed. He had succumbed five years ago, to malignant angina."

Knowing Bretonneau's ideas on contagion, Trousseau wrote further down: "I shall have the beds and bedding burnt, the paper hangings also, for they have a velvety and attractive surface; I shall tell the mother to purify herself like a Hindoo—else what would you say to me!"

A German of the name of Klebs discovered the bacillus of diphtheria in 1883, by studying the characteristic membranes; it was afterwards isolated by Loeffler, another German.

Pure cultures of this bacillus, injected on the surface of the excoriated fauces of rabbits, guinea-pigs, and pigeons, produce the diphtheritic membranes: Messrs. Roux and Yersin demonstrated this fact and ascertained the method of its deadly action.

Dr. Roux, in a lecture to the London Royal Society, in 1889, said: "Microbes are chiefly dangerous on account of the toxic matters which they produce." He recalled that Pasteur had been the first to investigate the action of the

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toxic products elaborated by the microbe of chicken-cholera. By filtering the culture, Pasteur had obtained a liquid which contained no microbes. Hens inoculated with this liquid presented all the symptoms of cholera. "This experiment shows us," continued M. Roux, "that the chemical products contained in the culture are capable by themselves of provoking the symptoms of the disease; it is therefore very probable that the same products are prepared within the body itself of a hen attacked with cholera. It has been shown since then that many pathogenic microbes manufactured these toxic products. The microbes of typhoid fever, of cholera, of blue pus, of acute experimental septicæmia, of diphtheria, are great poison-producers. The cultures of the diphtheria bacillus particularly are, after a certain time, so full of the toxin that, without microbes, and in infinitesimal doses, they cause the death of the animals with all the signs observed after inoculation with the microbe itself. The picture of the disease is complete, even presenting the ensuing paralysis if the injected dose is too weak to bring about a rapid death. Death in infectious diseases is therefore caused by intoxication."

This bacillus, like that of tetanus, secretes a poison which reaches the kidneys, attacks the nervous system, and acts on the heart, the beats of which are accelerated or suddenly arrested. Sheltered in the membrane like a foe in an ambush, the microbe manufactures its deadly poison. Diphtheria, as defined by M. Roux, is an intoxication caused by a very active poison formed by the microbe within the restricted area wherein it develops.

It was sufficient to examine a portion of diphtheritic membrane to distinguish the diphtheritic bacilli, tiny rods resembling short needles laid across each other. Other microbes were frequently associated with these bacilli, and it became necessary to study microbial associations in

diphtheria. The Klebs-Loeffler bacillus, disseminated in broth, gave within a month or three weeks a richly toxic culture; the bottom of the vessel was covered with a thick deposit of microbes, and a film of younger bacilli floated on the surface. By filtering this broth and freeing it from microbes, Messrs. Roux and Yersin made a great discovery: they obtained pure toxin, capable of killing, in forty-eight hours, a guinea-pig inoculated with one tenth of a cubic centimeter of it.

Now that the toxin was found, the remedy, the antitoxin, could be discovered. This was done by Behring, a German scientist, and by Kitasato, a Japanese physician. Drs. Richet and Héricourt had already opened the way in 1888, while studying another disease.

M. Roux inoculated a horse with diphtheritic toxin mitigated by the addition of iodine, in doses, very weak at first, but gradually stronger; the horse grew by degrees capable of resisting strong doses of pure toxin. It was then bled by means of a large trocar introduced into the jugular vein, the blood received in a bowl was allowed to coagulate, and the liquid part of it, the serum, was then collected; this serum was antitoxic, antidiphtheritic—in one word, the long-desired cure.

At the beginning of 1894, M. Roux had several horses rendered immune by the above process. He desired to prove the efficiency of the serum in the treatment of diphtheria, with the collaboration of MM. Martin and Chaillou, who had, both clinically and bacteriologically, studied more than 400 cases of diphtheria.

There are in Paris two hospitals where diphtheritic children are taken in. It was decided that the new treatment should be applied at the hospital of the *Enfants Malades*, whilst the old system should be continued at the Hôpital Trousseau.

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From February 1, MM. Roux, Martin, and Chaillou paid a daily visit to the *Enfants Malades*; they treated all the little diphtheria patients by injection, in the side, of a dose of twenty cubic centimetres of serum, followed, twenty-four hours later, by another dose of twenty, or only of ten cubic centimetres. Almost invariably, not only did the membranes cease to increase during the twenty-four hours following the first injection, but they began to come away within thirty-six or forty-eight hours, the third day at the latest; the livid, leaden paleness of the face disappeared: the child was saved.

From 1890 to 1893 there had been 3,971 cases of diphtheria, fatal in 2,029 cases, the average mortality being therefore 51 per 100. The serum treatment, applied to hundreds of children, brought it down to less than 24 per 100 in four months. At the Trousseau Hospital, where the serum was not employed, the mortality during the same period was 60 per 100.

In May, M. Roux gave a lecture on diphtheria at Lille, at the request of the Provident Society of the Friends of Science, which held its general meeting in that town. Pasteur, who was president of the Society, came to Lille to thank its inhabitants for the support they had afforded for forty years to the Society.

The master and his disciple were received in the Hall of the Industrial Society. Pasteur listened with an admiring emotion to his pupil, whose rigorous experimentation, together with the beauty of the object in view, filled him with enthusiasm. He who had said, "Exhaust every combination, until the mind can conceive no others possible," was delighted to hear the methodical exposition of the manner in which this great problem had been attacked and solved.

At the Hygiene and Demography Congress at Budapest, M. Roux, repeating and enlarging his lecture, made

a communication on the serotherapy of diphtheria which created a great sensation in Europe.

In France, prefects asked the Minister of the Interior how local physicians might obtain this anti-diphtheritic serum. The *Figaro* newspaper opened a subscription towards preserving children from croup; it soon reached more than a million francs. The Pasteur Institute was now able to build stables, buy a hundred horses, render them immune, and constitute a permanent organization for serotherapy. In three months, 50,000 doses of serum were about to be given away.

Pasteur, who was then at Arbois, followed every detail with passionate interest. Sitting under the old quinces in his little garden, he read the lists of subscribers, names of little children, offering charitable gifts as they entered this life, and names of sorrowing parents, giving in the names of dear lost ones.

When he started again for Paris, October 4, 1894, Pasteur was seized again with the melancholy feeling which had attended his first departure from his home, when he was sixteen years old. He saw the same grey sky, the same fine rain and misty horizon, as he looked for the last time upon the distant hills and wide plains he loved, perhaps conscious that it was so. But he remained silent, as was his wont when troubled by his thoughts, his sadness only revealing itself to those who lovingly watched every movement of his countenance.

On October 6, the Pasteur Institute was invaded by a crowd of medical men; M. Martin gave a special lecture in compliance with the desire of many practitioners unaccustomed to laboratory work, who desired to understand the diagnosis of diphtheria and the mode in which the serum should be used. Pasteur, from his study window, was watching all this coming and going in his Institute. A

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twofold feeling was visible on his worn features: a sorrowing regret that his age now disarmed him for work, but also the satisfaction of feeling that his work was growing day by day, and that other investigators would, in a similar spirit, pursue the many researches which remained to be undertaken. About that time, M. Yersin, now a physician in the colonies, communicated to the *Annals of the Pasteur Institute* the discovery of the plague bacillus. He had been desired to go to China in order to study the nature of the scourge, its conditions of propagation and the most efficient means of preventing it from attacking the French possessions. Pasteur had long recognized very great qualities in this pupil whose habits of silent labour were almost those of an ascete. M. Yersin started with a missionary's zeal. When he reached Hong-Kong, three hundred Chinese had already succumbed, and the hospitals of the colony were full; he immediately recognized the symptoms of the bubonic plague, which had ravaged Europe on many occasions. He noticed that the epidemic raged principally in the slums occupied by Chinese of the poorer classes, and that, in the infected quarters, there were a great many rats, which had died of the plague. Pasteur read with the greatest interest the following lines, so exactly in accordance with his own method of observation: "The peculiar aptitude to contract plague possessed by certain animals," wrote M. Yersin, "enabled me to undertake an experimental study of the disease under very favourable circumstances; it was obvious that the first thing to do was to look for a microbe in the blood of the patients and in the bubonic pulp." When M. Yersin inoculated rats, mice, or guinea-pigs with this pulp, the animals died, and he found several bacilli in the ganglions, spleen and blood. After some attempts at cultures and inoculations, he concluded thus: "The plague is a contagious and

inoculable disease. It seems likely that rats constitute its principal vehicle, but I have also ascertained that flies can contract the disease and die of it, and may therefore become agents for its transmission."

At the very time when M. Yersin was discovering the specific bacillus of the plague in the bubonic pulp, Kitasato was making similar investigations. The foe now being recognized, hopes of vanquishing it might be entertained.

And whilst those good tidings were arriving, Pasteur was reading a new work by M. Metchnikoff, a Russian scientist, who had elected to come to France for the privilege of working by the side of Pasteur. M. Metchnikoff explained by the action of the white corpuscles of the blood, named "leucocytes," the immunity or resistance, either natural or acquired, of the organism against a defined disease. These corpuscles may be considered as soldiers entrusted with the defence of the organism against foreign invasions. If microbes penetrate into the tissues, the defenders gather all their forces together and a free fight ensues. The organism resists or succumbs according to the power or inferiority of the white blood-cells. If the invading microbe is surrounded, eaten up and ingested by the victorious white corpuscles (also named *phagocytes*), the latter find in their victory itself fresh reserve forces against a renewed invasion.

On November 1, in the midst of all this laborious activity and daily progress, Pasteur was about to pay his daily visit to his grandchildren, when he was seized by a violent attack of uræmia. He was laid on his bed and remained nearly unconscious for four hours; the sweat of agony bathed his forehead and his whole body, and his eyes remained closed. The evening brought with it a ray of hope; he was able to speak, and asked not to be left alone.

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Immediate danger seemed avoided, but great anxiety continued to be felt.

It was easy to organize a series of devoted nurses; all Pasteur's disciples were eager to watch by his bedside. Every evening, two persons took their seats in his room: one a member of the family, and one a "Pastorian." About one a.m., they were replaced by another Pastorian and another member of the family. From November 1 to December 25, the laboratory workers continued this watching, regulated by Dr. Roux as follows:—

Sunday night, Roux and Chantemesse; Monday, Queyrat and Marmier; Tuesday, Borrel and Martin; Wednesday, Mesnil and Pottevin; Thursday, Marchoux and Viala; Friday, Calmette and Veillon; Saturday, Renon and Morax. A few alterations were made in this order; Dr. Marie claimed the privilege. M. Metchnikoff, full of anxiety, came and went continually from the laboratory to the master's room. After the day's work, each faithful watcher came in, bringing books or notes, to go on with the work begun, if the patient should be able to sleep. In the middle of the night, Mme. Pasteur would come in and send away with a sweet authority one of the two volunteer nurses. Pasteur's loving and faithful wife was straining every faculty of her valiant and tender soul to conjure the vision of death which seemed so near. In spite of all her courage, there were hours of weakness, at early dawn, when life was beginning to revive in the quiet neighbourhood, when she could not keep her tears from flowing silently. Would they succeed in saving him whose life was so precious, so useful to others? In the morning, Pasteur's two grandchildren came into the bedroom. The little girl of fourteen, fully realizing the prevailing anxiety, and rendered serious by the sorrow she struggled to hide, talked quietly with him. The little boy, only eight years old, climbed on

to his grandfather's bed, kissing him affectionately and gazing on the loved face which always found enough strength to smile at him.

Dr. Chantemesse attended Pasteur with an incomparable devotion. Dr. Gille, who had often been sent for by Pasteur when staying at Villeneuve l' Etang, came to Paris from Garches to see him. Professor Guyon showed his colleague the most affectionate solicitude. Professor Dieulafoy was brought in one morning by M. Metchnikoff; Professor Grancher, who was ill and away from Paris hurried back to his master's side.

How often did they hang over him, anxiously following the respiratory rhythm due to the uræmic intoxication! movements slow at first, then rapid, accelerated, gasping, slackening again, and arrested in a long pause of several seconds, during which all seemed suspended.

At the end of December, a marked improvement took place. On January 1, after seeing all his collaborators, down to the youngest laboratory attendant, Pasteur received the visit of one of his colleagues of the Académie Française. It was Alexandre Dumas, carrying a bunch of roses, and accompanied by one of his daughters: "I want to begin the year well," he said: "I am bringing you my good wishes." Pasteur and Alexandre Dumas, meeting at the Academy every Thursday for twelve years, felt much attraction towards each other. Pasteur, charmed from the first by this dazzling and witty intellect, had been surprised and touched by the delicate attentions of a heart which only opened to a chosen few. Dumas, who had observed many men, loved and admired Pasteur, a modest and kindly genius; for this dramatic author hid a man thirsting for moral action, his realism was lined with mysticism, and he placed the desire to be useful above the hunger for fame.

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His blue eyes, usually keen and cold, easily detecting secret thoughts and looking on them with irony, were full of an expression of affectionate veneration when they rested on "our dear and great Pasteur" as he called him. Alexandre Dumas' visit gave Pasteur very great pleasure ; he compared it to a ray of sunshine.

As he could not go out, those who did not come to see him thought him worse than he really was. It was therefore with great surprise that people heard that he would be pleased to receive the old Normaliens, who were about to celebrate the centenary of their school, and who, after putting up a memorial plate on the small laboratory of the Rue d'Ulm, desired to visit the Pasteur Institute. They filed one after another into the drawing-room on the first floor. Pasteur, seated by the fire, seemed to revive the old times when he used to welcome young men into his home circle on Sunday evenings. He had an affectionate word or a smile for each of those who now passed before him, bowing low. Every one was struck with the keen expression of his eyes ; never had the strength of his intellect seemed more independent of the weakness of his body. Many believed in a speedy recovery and rejoiced. "Your health," said some one, "is not only national but universal property."

On that day, Dr. Roux had arranged on tables, in the large laboratory, the little flasks which Pasteur had used in his experiments on so-called spontaneous generation, which had been religiously preserved ; also rows of little tubes used for studies on wines ; various preparations in various culture media ; microbes and bacilli, so numerous that it was difficult to know which to see first. The bacteria of diphtheria and bubonic plague completed this museum.

Pasteur was carried into the laboratory about twelve o'clock, and Dr. Roux showed his master the plague bacillus

through a microscope. Pasteur, looking at these things, souvenirs of his own work and results of his pupils' researches, thought of those disciples who were continuing his task in various parts of the world. In France, he had just sent Dr. Calmette to Lille, where he soon afterwards created a new and admirable Pasteur Institute. Dr. Yersin was continuing his investigations in China. A Normalien, M. Le Dantec, who had entered the Ecole at sixteen at the head of the list, and who had afterwards become a curator at the laboratory, was in Brazil, studying yellow fever, of which he very nearly died. Dr. Adrien Loir, after a protracted mission in Australia, was head of a Pasteur Institute at Tunis. Dr. Nicolle was setting up a laboratory of bacteriology at Constantinople. "There is still a great deal to do!" sighed Pasteur as he affectionately pressed Dr. Roux' hand.

He was more than ever full of a desire to allay human suffering, of a humanitarian sentiment which made of him a citizen of the world. But his love for France was in no wise diminished, and the permanence of his patriotic feelings was, soon after this, revealed by an incident. The Berlin Academy of Sciences was preparing a list of illustrious contemporary scientists to be submitted to the Kaiser with a view to conferring on them the badge of the Order of Merit. As Pasteur's protest and return of his diploma to the Bonn University had not been forgotten, the Berlin Academy, before placing his name on the list, desired to know whether he would accept this distinction at the hands of the German Emperor. Pasteur, while acknowledging with courteous thanks the honour done to him as a scientist, declared that he could not accept it.

For him, as for Victor Hugo, the question of Alsace-Lorraine was a question of humanity; the right of peoples to dispose of themselves was in question. And by a bitter

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irony of fate, France, which had proclaimed this principle all over Europe, saw Alsace torn away from her. And by whom? by the very nation whom she had looked upon as the most idealistic, with whom she had desired an alliance in a noble hope of pacific civilization, a hope shared by Humboldt, the great German scientist.

It was obvious to those who came near Pasteur that, in spite of the regret caused in him by the decrease of his physical strength, his moral energy remained unimpaired. He never complained of the state of his health, and usually avoided speaking of himself. A little tent had been put up for him in the new garden of the Pasteur Institute, under the young chestnuts, the flowers of which were now beginning to fall, and he often spent his afternoons there. One or other of those who had watched over him through the long winter nights frequently came to talk with him, and he would inquire, with all his old interest, into every detail of the work going on.

His old friend Chappuis, now Honorary Rector of the Academy of Dijon, often came to sit with him under this tent. Their friendship remained unchanged though it had lasted more than fifty years. Their conversation now took a yet more exalted turn than in the days of their youth and middle age. The dignity of Chappuis' life was almost austere, though tempered by a smiling philosophy.

Pasteur, less pre-occupied than Chappuis by philosophical discussions, soared without an effort into the domain of spiritual things. Absolute faith in God and in Eternity, and a conviction that the power for good given to us in this world will be continued beyond it, were feelings which pervaded his whole life; the virtues of the Gospel had ever been present to him. Full of respect for the form of religion which had been that of his forefathers, he came to

it simply and naturally for spiritual help in these last weeks of his life.

On June 13, he came, for the last time, down the steps of the Pasteur Institute, and entered the carriage which was to take him to Villeneuve l'Etang. Every one spoke to him of this stay as if it were sure to bring him back to health. Did he believe it? Did he try, in his tenderness for those around him, to share their hopes? His face almost bore the same expression as when he used to go to Villeneuve l'Etang to continue his studies. When the carriage passed through Saint Cloud, some of the inhabitants, who had seen him pass in former years, saluted him with a mixture of emotion and respectful interest.

At Villeneuve l'Etang, the old stables of the Cent Gardes had reverted to their former purpose and were used for the preparation of the diphtheria anti-toxin. There were about one hundred horses there; old chargers, sold by the military authorities as unfit for further work; racehorses thus ending their days; a few, presents from their owners, such as Marshal Canrobert's old horse.

Pasteur spent those summer weeks in his room or under the trees on the lawns of the Park. A few horses had been put out to grass, the stables being quite full, and occasionally came near, looking over their hurdles towards him. Pasteur felt a deep thankfulness in watching the busy comings and goings of Dr. Roux and his curator, M. Martin, and of the veterinary surgeon, M. Prévôt, who was entrusted with the bleeding operations and the distribution of the flasks of serum. He thought of all that would survive him and felt that his weakened hand might now drop the torch which had set so many others alight. And, more than resigned, he sat peacefully under a beautiful group of pines and purple beeches, listening to the readings of Mme. Pasteur and of his daughter. They smiled on him

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with that valiant smile which women know how to keep through deepest anguish.

Biographies interested him as of yore. There was at that time a renewal of interest in memories of the First Empire; old letters, memoirs, war anecdotes were being published every day. Pasteur never tired of those great souvenirs. Many of those stories brought him back to the emotions of his youth, but he no longer looked with the same eyes on the glory of conquerors. The true guides of humanity now seemed to him to be those who gave devoted service, not those who ruled by might. After enjoying pages full of the thrill of battlefields, Pasteur admired the life of a great and good man, St. Vincent de Paul. He loved this son of poor peasants, proud to own his humble birth before a vainglorious society; this tutor of a future cardinal, who desired to become the chaplain of some unhappy convicts; this priest, who founded the work of the *Enfants Trouvés*, and who established lay and religious alliance over the vast domain of charity.

Pasteur himself exerted a great and charitable influence. The unknown lady who had put at his disposal four scholarships for young men without means, came to him in August and offered him the funds for a Pasteur Hospital, the natural outcome, she said, of the Pastorian discoveries.

Pasteur's strength diminished day by day, he now could hardly walk. When he was seated in the Park, his grandchildren around him suggested young rose trees climbing around the trunk of a dying oak. The paralysis was increasing, and speech was becoming more and more difficult. The eyes alone remained bright and clear; Pasteur was witnessing the ruin of what in him was perishable.

How willingly they would have given a moment of their lives to prolong his, those thousands of human beings

whose existence had been saved by his methods: sick children, women in lying-in hospitals, patients operated upon in surgical wards, victims of rabid dogs saved from hydrophobia, and so many others protected against the infinitesimally small! But, whilst visions of those living beings passed through the minds of his family, it seemed as if Pasteur already saw those dead ones who, like him, had preserved absolute faith in the Future Life.

The last week in September he was no longer strong enough to leave his bed, his weakness was extreme. On September 27, as he was offered a cup of milk: "I cannot," he murmured; his eyes looked around him with an unspeakable expression of resignation, love and farewell. His head fell back on the pillows, and he slept; but, after this delusive rest, suddenly came the gaspings of agony. For twenty-four hours he remained motionless, his eyes closed, his body almost entirely paralysed; one of his hands rested in that of Mme. Pasteur, the other held a crucifix.

Thus, surrounded by his family and disciples, in this room of almost monastic simplicity, on Saturday, September 28, 1895, at 4.40 in the afternoon, very peacefully, he passed away.

THE END.

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